DOCUMENT RESUME

ED 026 855 64 EM 007 002

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Instructional Television Facilities: A Planning Guide for Educational Administrators. Final Report.

Brooks Foundation, Santa Barbara, Calif.

Spons Agency-Office of Education (DHEW), Washington, D.C. Bureau of Research.

Bureau No-BR-7-1021

Pub Date Jun 68

Contract-OEC-1-7-071021-4429

Note-191p.

EDRS Price MF-$0.75 HC-$9.65

Descriptors-Broadcast Television, Closed Circuit Television, Community Antennas, *Consultants, *Educational Administration, Educational Television, *Fixed Service Television, Instructional Technology, *Instructional Television, Open Circuit Television, *School Administration, Television, Television Curriculum, Video Tape Recordings

As soon as the educational objectives of a proposed Instructional Television System (ITV) have been determined, professional technical advice should be obtained. In planning a system, there are many choices possible between various television production systems, transmission systems, reception facilities, and video recorders. The system chosen must meet initial objectives, mesh with other instruction technology in use, and allow for future expansion of the program. To facilitate communication with the consulting engineer, it would be useful to know the meaning of scanning linearity, gamma response, detail contrast, and video signal to noise ratio. Familiarity with the limitations and possibilities of orthicon and vidicon Television cameras, open and closed-circuit transmission, Instructional Television Fixed Service (ITFS), quadruplex and slant track video recorders, color capable and color compatible equipment will allow the educational administrator to make better use of professional advice. The staffing of an ITV project also requires some knowledge of the functions of the technical and production staff. Appendices offer specific information concerning consultant help in engineering, sources of information and programing, and a paper by the Federal Communications Commission on educational television. (JY)

ED0 26855

FINAL REPORT

Project No. - 925

Contract No. OEC-1-7-071021-4429

INSTRUCTIONAL TELEVISION FACILITIES:
A PLANNING GUIDE FOR EDUCATIONAL ADMINISTRATORS

June 1968

U. S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
Office of Education
Bureau of Research

ED026855

Title of Report

INSTRUCTIONAL TELEVISION FACILITIES: A PLANNING GUIDE FOR EDUCATIONAL ADMINISTRATORS

Project No. -925

Contract No. OEC-1-7-071021-4429

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June 1968

The research reported herein was performed pursuant to a Contract with the Office of Education, U. S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

BROOKS RESEARCH FOUNDATION

Santa Barbara, California 93103

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ACKNOWLEDGEMENTS

Now we know why people dedicate books to their wives and kids. Even in this modest venture, we've found that we can hope to contribute some amount of knowledge and experience, but families must add patience, understanding, and the time when Author should have been Father.

For much valuable counsel, we must express our appreciation also to educational administrators in many parts of the country. Their perspective -- both as colleagues and as the potential audience for our work -- has been crucial.

Another hardy band of colleagues gave painstaking study to the preliminary manuscript and made exceptionally cogent and useful comments. Much personal time was contributed in this effort by Robert L. Hilliard of the Federal Communications Commission, Frank W. Norwood of the Joint Council on Educational Telecommunications, Lewis A. Rhodes of the National Association of Educational Broadcasters, and Harold E. Wigren of the National Education Association. Raymond J. Stanley of the U. S. Office of Education was responsible for much of the preliminary design of the project, and he was a good shepherd as work progressed. For valuable assistance throughout, thanks go also to Michael J. Wilhelm of W. J. Kessler Associates.

But all this highpowered help notwithstanding, the undersigned are the ones who did the deed and who bear the responsibility.

JOHN P. WITHERSPOON
WILLIAM J. KESSLER

INSTRUCTIONAL TELEVISION FACILITIES: A PLANNING GUIDE FOR EDUCATIONAL ADMINISTRATORS

CHAPTER I

SOME REMARKS ON THE GIST OF THE PROBLEM

Introduction.

Aristotle (if we may begin with a really ironclad reference) was fond of the idea that the audience is the end and aim of the speech. Our audience, and the end and aim of our speech, is the educational administrator. Others may find this little book useful in various ways, but the man we are after is the man who finally says yes or no to a given instructional method or idea, and who commits his budget accordingly.

It is our observation that this man is too often forced to spend really significant money, and more importantly to make pervasive instructional decisions, after a study of information that is technically, pedagogically, and administratively incomplete and unnecessarily subjective. One more small book is not going to remedy that situation, but within the area of instructional television we can provide some simple technical cues that may if necessary be converted to danger signals; we can give some practical advice on, for example, what an administrator should expect of consultants; we can take a bit of the mystery out of the dark forest of television technology; and with a little bit of luck we can help the administrator place television in perspective as he contemplates his overall strategy of instruction.

If we were to distill the essential moral of our story into two simple sentences they would be:

1. Think first about educational objectives and second about technology.

2. Get expert advice before the planning process is far advanced. To put the burden of a book however modest, into two seemingly obvious sentences is patently to invite disaster. As you might guess, however, these matters are not quite as simple as they seem. Hardlyanybody will admit that he bought a television package without considering its uses. But an honest few, in the company of close friends, could be pressed to concede that the specific objectives chosen, and the specific equipment purchased, turned out to have rather little in common. Others, perhaps in less congenial company might put it differently: "We tried educational television and it didn't work."[1]

Educational television, as an instrument of instruction, has worked well in an enormous variety of situations. Its virtues have been tested in situations ranging from teacher-training classrooms (where it is often used as a self-observation device) to physician-training operating rooms, where it is used to give all students a better view than any of them could have in the familiar amphitheater. It has been used as a presentational tool for nearly any subject area taught in schools and colleges today, not excluding mathematics, typing, psychology, foreign languages, art, and physical education.

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[1] This line particularly infuriates people who work in educational communications, since it ignores poor planning and transfers blame to the medium. It's a little like swearing at a chair because you stubbed your toe on it.

Television is properly called a medium, along with books and chalkboards. Like the medium called "book" or the medium called "chalkboard", the medium called "television" offers a certain technical potential, a capacity for instructional utility, a set of advantages and limitations within which valuable things are possible. It is possible to use any of the media very well or very poorly.

Television has become available at a time of bewildering change in American education. Basic methods and techniques -- even basic assumptions -- have been questioned seriously. Slowly and painfully, education is being reshaped to make real the dreams of true educational equality, really individualized instruction, and instructional strategies based on behavioral science as well as on experience and intuition.

A great many administrators have recognized that television and other technology must play a part in this process of reshaping. But difficult problems arise. Some are related to philosophies of instruction; some are tied to questions of budget; and some have to do with the uncertainties of planning in an unfamiliar area with insufficient help. In the following pages we address ourselves mostly to the last of these three categories.

The Capabilities of Equipment.

Television equipment today is available in a baffling variety of types, packages, and ranges of capability. The newcomer must overcome the dangerous tendency to assume that two items are equal because they are called by the same name. To speak of a television camera," for example, is very much like speaking of "an automobile." Television cameras, like automobiles, have certain basic, common functions to perform. All automobiles provide transportation, and all television cameras convert light images into television signals. But the ideal car for freeway driving is hardly the optimum vehicle for churning over rutted back-country trails. Similarly, the television camera that is used to post flight information at metropolitan airports is not the camera used in the production of network drama.

To carry the comparison farther, consider the simple snapshot cameras that children get for Christmas. They may take excellent pictures, but the professionals at your local newspaper depend on somewhat more expensive models. It may be instructive to ask why.

When a man buys the more expensive camera -- to make pictures on ordinary roll film or to make pictures electronically for television -- he buys certain qualities, the most important of which are operating dependability, technical characteristics of the picture, and the ability of the camera to operate under widely varying light conditions.

That is not to say that a press photographer's camera is better in all ways than a child's Christmas camera. Santa Claus recognizes such virtues as operating simplicity and low cost. Besides, little Suzie just doesn't need a camera that will show every minute detail of every relative who consents to be a young photographer's subject.

Thus, the question to examine now is not which equipment is good or not-so-good, but which equipment is needed to achieve stated educational goals.

Needs and Goals.

It seems to be true that we get what we pay for. But it is possible to get what we pay for and still not get what we need.

The decision to install an instructional television system may not be quite as profound as the decision to build a building, but the two have some things in common. Television hardware lasts over a period of years. It bears on the work of other parts of the instructional effort. The investment represents a decision regarding the overall hierarchy of priorities, and thus affects the administrator's relations with others.

Television is used for a great range of tasks, including (but by no means limited to) the following:

1. Presentation of prepared instructional materials of various kinds to students in classrooms;
2. Presentation of instructional or broadly educational materials to people in their homes;
3. Presentation of experiences which are difficult to present in person, such as demonstrations of actual surgery to medical students or demonstrations of teaching techniques to groups of student teachers.
4. As an auto-instructional device to allow observation of one's own performance, as in classroom teaching situations, sports or many kinds of physical skills.

5. Simple surveillance for security purposes (as in apartment houses), posting of up-to-date information (as in airports), observation of laboratory processes dangerous to human observers, etc.
6. Image magnification, to show microscope slides to whole classes, detailed drawings or formulas to large groups, etc.

Within these broad categories there are great variations. Examine for instance, Category 1 above:

> Presentation of prepared instructional materials of various kinds to students in classrooms."

Compare the meaning of this statement as applied to a television station and to an individual school.

Within an educational television station, that requirement dictates a large studio, probably equipped with three high-quality cameras mounted on heavy, steerable pedestals a flexible lighting system, the capacity to handle at least half a dozen microphones, related picture and sound sources including professional quality film projectors, audio and video tape recorders, slide projection equipment, audio turntables, etc.; an intercommunication system connecting director, control room crew, and studio crew, sophisticated switching equipment for picture and sound, and latest equipment on which to record the finished product. This studio probably has the backup services of a fully equipped scene shop, electronic maintenance facility, photographic services, graphic production services, and professional management.

On the other hand, an individual school may, for its "presentation of prepared instructional materials of various kinds to students in classrooms," have an installation that receives the ETV station's signals off the air; plays back materials from a small video tape recorder or film projector; and displays these materials on classroom television sets of good quality. For its specialized needs, the school may also have one or two cameras of adequate if modest quality, a microphone or two; and a few lighting instruments. For their respective purposes, the television station and the school may both have installations they properly consider appropriate.

The lesson of the preceding paragraphs, obvious as it seems, is often overlooked: both installations are appropriate, both answer the same broad statement of need, but they are fundamentally dissimilar, and the product of one cannot be equated fairly with the product of the other.

Furthermore, the school's equipment and that of the ETV station probably differ not only in quantity, but in kind. The school needs equipment that is rugged, easy to operate and maintain, takes up little space, and is relatively inexpensive. The television station needs equipment that is as flexible as possible, generates picture and sound of highest possible quality, and can be used with varying lighting conditions and in situations that require unusual technical effects. Roughly speaking, the trade-offs are costs (both capital and operating) versus quality and flexibility.

When one examines other uses of television, still other factors intrude. Suppose your system is to be used for the simple observation of people or processes. The cameras most suited for that work are among the least expensive, and purchase of costly studio equipment usually would be in error technically as well as financially.

To return to our cardinal principles· (1) Start with carefully stated objectives; (2) Get qualified consultant help early.

As you begin serious discussion of a television installation, however, it will be worthwhile to consider a few guidelines contributed by others who have already been through the mill:

(1) It may be the innate virtues of television or it may be Parkinson's Law, but small systems grow. This fact has a couple of important implications:

a. Make enough of an investment in space that growth won't cause a major upheaval;

b. Buy equipment with an eye on uses a bit broader than the first planned applications. The inadequacies of many installations can be traced to the fact that people are "making do and "patching together" because their initial decisions were too restricted.

(2) Before you buy equipment, find out what other people are using. This is not merely a matter of sharing wisdom; you will probably want to exchange certain kinds of materials with other centers, and this is possible only if your equipment speaks the same electronic language as the equipment next door. More on this point in a later section.

(3) As in the purchase of everything from pencils to plumbing, the cheapest equipment may not be the best buy. Two prime requirements of electronic equipment are reliability and operating stability, and both cost money. Unsatisfactory equipment performance is one of the prime reasons why some people report that "We tried educational television and it didn't work."

(4) Look ahead as far as possible. The decision to use television is presumably in response to a present need, but the equipment will still be there when the context has changed. Educational communications is currently the subject of much long-range study and serious technological development. To ignore it as abstruse or futuristic is clearly unwise and ultimately uneconomical.

IN SUMMARY: Television can be used in a great many ways. Equipment needs vary considerably with the tasks to be performed. Careful survey of initial needs, and painstaking, informed determination of initial goals are essential to a really successful operation. At the same time, it is well to remember that systems grow and needs change, and in most situations it is unwise to work from a plan that does not easily permit this evolution.

Sources of ITV Materials.

In considering instructional television, many administrators fall into the habit of thinking about reception of broadcast materials in the classroom and/or production of materials locally. In fact, ITV materials take many routes to the classroom consumer, and systems should be designed with these various options in mind.

Briefly, the major paths are as follows:

1. Materials are produced locally for local consumption.
2. Materials are distributed to many users by national or regional centers. The ones that come to mind most often are the National Center for School and College Television in Bloomington, Indiana, and the Great Plains National Instructional Television Library in Lincoln, Nebraska.
3. Materials are exchanged between centers. These agreements are often informal, based on the simple realization that nobody has a corner on good teaching.

Once an interest in television has been established, many institutions plan immediately for local production, on the premise that nothing presently available quite suits the local situation. As a practical matter, an evolutionary process often takes place. This evolution is as follows:

1. It is decided that local needs are unique in various ways, and the local institution acquires a production capability.
2. To the extent that local needs really are unique, the production efforts remain local. Typically, this area of uniqueness is not nearly as great as earlier estimates indicated.
3. It is discovered that nationally distributed materials are available in better quantity and quality than earlier estimates indicated. Furthermore, television uses are expanding to the extent that local production could not cope if it had to do the job alone.

4. Certain local programs are "discovered by nearby systems, and they are traded for some of the better programs of these neighbors. With the incentive of broader distribution, and with local pride at stake, greater effort is invested in these programs, and the quality goes up.

5. The best of these efforts are discovered" by the National Center for School and College Television or the Great Plains ITV Library. Adjustments are made to upgrade production or to make the programs valid nationally, and they go into nationwide distribution.

This pattern has some specific implications for system design: if exchanges are to take place, equipment must be compatible. This is a matter which should be given serious study and about which there should be ample expert advice, and the question should be raised: Is local production really a requirement? Have national sources now developed sufficiently that our local needs really are served? Rapid advances have been made in recent years, unless your need is self-evidently unique, a careful, open-minded study of ITV sources is in order. Television production is too expensive if it is merely in the "nice to have" category.

Appropriate System Design.

From the foregoing, it can be seen that television planning should survive some tough tests before it is translated into hardware and payroll. Among the major questions to be asked by the educational administrator are these:

1. What is the list of educational needs before me?

What are the realistic priorities which I must adhere to?

2. Precisely how should television fit into this context? Exactly what should it do?

3. What is ahead in the whole relationship between education and technology? How are we likely to be using our television system in five years? Ten years?

4. In our areas of need, what television materials are now available? What other television centers exist, and how are we likely to relate to them?

5. Concerning our television plan: In terms of space, hardware, and personnel, precisely how is it responsive to the previous four points?

CHAPTER II

RELATING ITV TO OTHER INSTRUCTIONAL TECHNOLOGY

The facilities of instructional television constitute the focus of this little book. By and large, it is beyond our present scope to consider specifics of utilization or ways in which ITV fits into the basic strategy of education in your situation. Nevertheless, it seems desirable to relate television briefly to other media and other techniques.

The slogan for this section is "The Right Medium for the Job." As we press into the final third of our century, the range of available media becomes more and more impressive. In addition to television, technological development provides us with radio, programmed instruction, films, slides and other still pictures, computer-aided learning systems, audio devices such as language laboratories, dial-access information systems in learning carrels, blackboard-by-wire, and (just on the horizon) applications of slow-scan television and facsimile.

As one considers the right medium for the job, he is forced to abstract the characteristics of the techniques available. For example, we may say that television provides:

1. Sound of reasonably high quality;
2. Pictures of moderately good resolution;
3. The illusion of motion;
4. Color as an option at considerable cost;

5. Instant transmission if needed, or use from videotape;
6. Relative ease of classroom use on familiar receiving equipment.

Taken alone, however, television does not provide student feedback, and the student's pace is determined heavily by the present distribution pattern of the material.

Compare this list with that which might be developed for other media. Computer-aided learning systems have instant feedback, a more individualized approach to learning, and are capable of displaying material of various kinds; but the per-student cost is much higher and the system is not presently useful for displaying information to large groups. Radio has many of the distributional advantages of television and, if one may sacrifice video in given cases, offers impressive advantages in terms of economy and efficiency. There is, incidentally, research evidence to the effect that we often spend large amounts of money to provide the illusion of motion and/or color in situations where these components actually detract from learning.

As modern technology is more commonly used in education, it becomes possible through sheer volume to use it better. As more media are added to the arsenal, it becomes possible to ask questions about their relationships with each other. If a major school system has at its disposal a well-equipped audio-visual center, a television system, a radio station, and perhaps a computer-aided learning project, its administrators may ask which technique is best for which job, and also how various media and techniques can be used in combination. As examples, here are some of the combinations now in use:

a. A radio station is used to provide a second sound track in another language for a television program.

b. An FM stereo station carries an orchestra's music while a television station broadcasts the picture.

c. A radio station carries lecture material in conjunction with locally-projected color slides.

d. A radio or television station uses telephone lines to provide feedback from students or classes.

e. Various production sources prepare materials for display in dial-access or computer-mediated learning systems.

f. Telephone techniques are used for distant speakers, questions from audiences, and transmission of "notes" via electrowriter or blackboard-by-wire systems.

Many other variations could be reported, but these present the essential lesson: (1) decide on objectives; (2) survey the facilities available, (3) choose a strategy that is likely to achieve the objectives while making most efficient and economical use of available resources. A secondary lesson: Try to avoid over-commitment to one medium or one technique. To illustrate, we turn to a situation in which the right medium was not television, but an exceptionally imaginative radio system.

A Case Study in Ingenuity:

Radio Station WAMC, Albany Medical College

When it comes to relating educational objectives, efficient and economical use of facilities available, and long-range good results, Exhibit A is an educational FM station operated by the Department of Postgraduate Medicine, the Albany Medical College of Union University. Through an arrangement that is at once charmingly simple and devastatingly ingenious, Station WAMC is headquarters for an operation that takes illustrated lectures in postgraduate medicine to physicians located in about 70 hospitals in eight states, and then allows the physicians to ask questions of the lecturer while the other "seminar" participants listen. Participating faculty members, who appear live, are from medical schools as widely separated as the University of Vermont, Yale, Johns Hopkins, the University of North Carolina, the University of Rochester, and the University of Wisconsin. Approximately 30 medical schools participate in the project, which has been underway since 1958.

Some of the resources used are as follows:

1. Station WAMC Albany and three other educational FM stations, located in New York, Boston, and Canton, N.Y.
2. Class D Telephone lines;
3. Cable TV systems;
4. Radio relays of the sort used by taxicab companies to dispatch cabs.;

5. Multiple copies of high-quality color slides projected locally in the hospitals;
6. The secondary-channel multiplex capabilities of FM stations;
7. Audio tape recordings.

Imagine that one of the two-way radio conferences is about to begin. On this particular day, the subject is "Serum Enzymes in Diagnosis," and the visiting faculty members are W. T. W. Clarke and Alan Pollard, both of the University of Toronto. They are in an office at their university. This particular session is addressed to physicians in 15 hospitals in four states. In each hospital, the doctors are gathered around a table in a room that also contains an FM radio, a slide projector and screen, and a supply of box lunches (It has been found that lunchtime is the ideal period for these people to gather). Each room also has a small "black box" transmitting device and a microphone. By pushing a button on the box and speaking into the microphone, this seminar group is in touch with all the other groups and with the guest lecturers.

The broadcast begins at noon sharp. In Albany a moderator sits in the WAMC studio. He invites the participating hospitals to check in. They do so: Pittsfield, Massachusetts; Lewiston, Maine; Cohoes, New York; Hartford, Connecticut; Biddleford, Maine; and so on. As each hospital chairman pushes the button on his transmitter,a labelled light goes on in the WAMC studio's "electronic hand-raiser" and as the local hospital chairman speaks, his voice is heard by the other participants throughout the Northeast.

Then the lecture begins. The voices of Drs. Clarke and Pollard come initially not from Toronto, but by high-quality tape recording played from Albany. This is both a convenience and an economy measure. A low-cost phone line from their office to the studio is of sufficient quality for short answers to questions, but it would be annoying for a full half-hour lecture. Also, the use of the recording eliminates the need for the visiting experts to repeat their lecture in a subsequent session for other hospitals.

From time to time, the taped voice of Dr. Clarke or Dr. Pollard directs attention to a slide, one of perhaps 25 that had been duplicated and shipped in advance to the hospital.

As the lecture progresses, questions or comments occur to participants at the various hospitals. To signify that its members wish to be recognized, a group presses the button on its transmitter, and in the WAMC studio a light goes on just below a small label that says "Maine Med. Ctr. Portland" or "Mt. Sinai, Hartford, Conn." At the conclusion of the lecture, the moderator calls on the hospital groups that have signalled. Through an ingeniously inexpensive relay system, the question or comment is stated. The visiting faculty members -- now speaking from their Toronto headquarters -- respond. This multi-state, international dialogue continues for half an hour.

At precisely 1:00 P.M., the program ends.

A project as far-flung and as impressively useful as this would be presumed to carry an equally weighty price tag. But the whole operation is housed in a comfortable post-Victorian house in Albany, and there is room left for other activities as well. The manager of WAMC, Albert P. Fredette, presides with cheerful enthusiasm from a study that still contains its oak mantelpiece bearing the impressively carved legend "Here Forget Your Care."

Since 1958, the total investment in studios, control room, transmitter (located atop Mount Graylock), studio-transmitter microwave link, recording and duplicating facilities, test equipment, plus all the hospital-based equipment, has amounted only to $175,000. The annual operating cost is just $120,000. There are seven staff members in administration, engineering, programming, and production, plus four clerical positions and three part-time students who operate the control board. In addition, seven members of the College's Department of Postgraduate Medical Education are regularly involved.

And when the station's medical work is done, it provides an impressive schedule of noncommercial radio programming for listeners at home. The cost of that function is included in the figures above.

The major point, however, is not economy, but the fact that this is a well-developed, thoroughly appropriate solution to a specific problem. It is a valid means to the realization of carefully defined objectives.

Projections of multi-media system development

Suppose you decide today to invest in an instructional television system. Before the initial equipment reaches the end of its useful life, you will probably have to decide how your ITV facility should evolve into, or at least relate to, a larger multipurpose educational communications activity. That seems a safe prediction because of the following succession of developments:

(A) During the late 1950's there was serious planning among the Big Ten universities about ways in which a Big Ten radio network might be developed so as to offer a whole range of information and communication services to their institutions. A preliminary study of the matter was conducted by Carl Menzer, the veteran broadcaster heading Station WSUI at the University of Iowa.

(B) In 1962, the National Association of Educational Broadcasters began its Educational Communications System project, based on the hypothesis that a truly multipurpose communications system could be of academic, administrative, and economic importance to American colleges and universities. The notion was warmly received by the institutions. Pilot networks were designed, involving the members of the Committee on Institutional Cooperation (The Big Ten and the University of Chicago); the Oregon State System of Higher Education; and an East Coast model emphasizing non-academic" institutions that have considerable contact with universities (major research libraries and laboratories, etc.).

(C) At approximately the same time, there emerged independently the Interuniversity Communications Council (EDUCOM), which developed from the field of medicine but which moved to embrace many disciplines and many communication modes.

(D) Major computer-oriented projects such as MEDLARS at the National Library of Medicine demonstrated the large-scale use of current information in electronic data form.

(E) Several technological developments immediately lent even greater currency to these developments. Chief among these was the great surge in the use of computers and the increasing utility of communications satellites. There were studies involving the use of satellites to serve regions, or even as the core of communication systems in individual major states such as California. There was considerable discussion of the use of satellites for the exchange of computer data, utilizing broadband channels and very high transmission rates. Satellite-to-home television systems were shown to be practical if not imminent.

(F) In his remarks on signing the Public Broadcasting Act of 1967, in November of that year, President Johnson laid great stress on a worldwide Network for Knowledge which would incorporate broadcast communications media, computer systems, and satellite transmission systems for the benefit of education around the world. His remarks were immediately amplified by Leonard Marks, Director of the U. S. Information Agency. Almost as immediately, Comsat expressed its readiness to begin domestic experimentation in the field. The Networks for Knowledge Act was introduced in Congress in 1968.

(G) Patterns of business organization followed (and in some cases led) the rapid technological development. For example, the General Learning Corporation was formed by General Electric and

Time, Inc., which ten years earlier would have seemed an unlikely combination. A complex of mergers and working relationships developed among major electronics firms and communication companies, publishers, and computer firms. The close relationship between hardware and software was becoming evident, and caused major complications in the overhaul of the United States copyright law.

We can predict with some confidence, then, that today's instructional television system will face a challenging and perplexing evolution during the next decade. The authors wish, for your peace of mind and theirs, that they could chart the evolution with precision. Since that is not possible, we must settle for some principles and guidelines that will be expanded in subsequent sections.

1. Build a reasonable amount of excess capacity into your system.
2. Use equipment that is as broadly compatible as possible.
3. Where possible, build in modular units, so that important changes and additions can be made with a minimum of extra cost.
4. Before you start, get the best consulting help you can afford, both in engineering and in system design at the level of operating policy.
5. Build a financial capacity for change into future budget projections.
6. Assure that principal staff people have every opportunity to stay abreast of technical developments, experimental projects, and operations of major centers elsewhere.

CHAPTER III

A NOT-VERY-FORMIDABLE INTRODUCTION TO VIDEO ENGINEERING

Too many people turn away from engineering fundamentals that are not all that difficult. True, the educational administrator is properly more concerned about tax rates than about scanning rates, and integrated schools are a greater challenge than integrated circuits. But when the equipment salesman comes calling, there tends to be a lot of talk about quality and cost and maintenance and operational dependability. When that time comes, it pays to have some acquaintance with the rules of the game.

No one should feel abashed at being unable to follow all of an engineer's technical talk; if you want to see a really blank expression, speak to the engineer in late-model educationese. Drop terms like transformational grammar or transactional psychology. Ask him his opinion of modular schedules, or even something as old hat as SMSG. As Will Rogers pointed out, "We're all ignorant -- only on different subjects."

What follows, then, is an unpretentious discussion of some basics. Having mastered these rather simple ideas, you can speak with confidence to engineers, and you can absolutely buffalo your colleagues.

The Test Pattern Concept

When an engineer evaluates a television system, one of his most valuable tools is the EIA[1] test pattern. This is nothing more than a "standard picture," and the engineer is so familiar with it that he remembers all its minute details. When he sees the EIA test pattern as rendered by various parts of a television system, he can diagnose troubles and assess various picture impairments accurately and objectively.

For our purposes, the EIA test pattern tells more than we need to know. We can safely reduce the number of TV picture characteristics to four. The engineer, in his accurate but opaque way, refers to these as:

1. Scanning linearity;
2. Gamma response;
3. Detail contrast;
4. Video signal-to-noise ratio.

In ordinary English, these become:

1. Geometric accuracy of the TV image;
2. Gray-scale reproduction;
3. Resolution;
4. Picture-to-snow ratio.

Let's consider them one at a time.

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[1] EIA, Electronics Industries Association, which sets various technical standards.

Geometric accuracy

Looking at the picture, are the circles round? Are the squares square? Geometric distortion is the skewing or stretching of the reproduced picture. It occurs when the picture tube "paints", or scans, the picture at uneven off-standard speeds. Scanning part of the picture too fast stretches the image; scanning that is too slow squeezes it. Note the circles in Figure 11. This problem can occur in the originating camera or in the TV set. Unlike other common impairments, this one is caused only by the camera or the receiver; none of the intermediate hardware has anything to do with geometric accuracy.

Gray-scale reproduction

In a television system there are ten evenly-spaced standard shades of gray, ranging from reference white to reference black. A system of good quality, well maintained and in good adjustment, will see and display them all. If the system is of lesser quality, poorly maintained, or out of adjustment, the gray scale response will be unbalanced. The picture may be washed-out white or muddy dark.

Resolution

A system's resolution is of course its ability to show fine detail in the reproduced image. The problem of reproducing small details in a TV picture is very similar to that faced by newspaper or magazine publishers. The major difference is that while the publishing industry uses a dot structure to reproduce photographic half-tones, television uses a system of horizontal lines. These differences are illustrated in Figures 4 and 5. Obviously, resolution is determined in print by the number of dots per square inch and in television by the number of lines per inch.

There is, however, an additional complication. A look at the dot structure of a printed picture will easily demonstrate that there is equal resolution horizontally and vertically. In television, alas, this is not the case.

The television picture is composed of a standard number of horizontal lines; in the United States, the standard number is 525. Since there are always 525 lines between the top of the picture and the bottom, it's easy to guess that vertical resolution is not going to vary much. Some of these lines are displaced by synchronizing pulses, and some are effectively cancelled by small scanning errors, but vertical resolution in any good system will turn out to be about 370 lines.

Horizontal resolution is another matter. It is not primarily related to scanning standards but to a characteristic called video bandwidth. It isn't necessary for us to launch into a treatise on video bandwidth; we can settle for the general statement that if one wishes to increase horizontal resolution, he increases video bandwidth.[1] Different television systems use video bandwidths ranging from as low as two megahertz[2] to perhaps 12 mHz. A common video bandwidth is 4.2 mHz, since that is the theoretical point at which horizontal resolution equals vertical resolution.

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[1] As you might have guessed, video bandwidth costs money. The cheaper videotape recorders, for example, use relatively narrow bandwidths and have relatively poor horizontal resolution.

Without going into detail, it should be observed also that there are several other matters that affect resolution, most of them controlled by good maintenance practices.

Picture-to-snow ratio

Any viewer knows what television snow looks like, and he knows that it is to be avoided. It is the video equivalent of hissing or static on your radio or telephone: random electrical disturbances that are omnipresent in varying amounts in any communication system.

The object of the television system is to present lots of picture with very little snow, since snow reduces clarity, serves to divide the focus of attention, and generally detracts from the usefulness of the picture. We wish, then, to design systems with a high picture-to-snow ratio. Or, to be a little more precise, we need systems with a high video signal-to-noise ratio.

Although the engineer has no objective means to measure the picture and snow levels as they appear on the television screen, he can measure the video signal-to-noise ratio at the input to the receiver, and he can do it in terms that are accurate, convenient, and universally understood.[1]

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[2] Hertz: one cycle per second; Megahertz: one million cycles per second. Its symbol is mHz. This term is discussed further in a later part of this chapter.

A New Look at Test Patterns

For the purposes of this book, we have devised a special kind of test pattern, or standard picture, to illustrate the four basic characteristics of television systems.[2] This standard picture is shown in Figure 6. See how it works:

1. Geometric distortions can be seen in the shapes and relative sizes of the circles and squares.
2. Gray-scale reproduction is shown by the varying gray shades inside the circles. Numbers are imbedded in the gray circles, and the shade of the number is exactly one shade darker than its background. Reference white (standard shade of grav number one) is shown in the upper left circle. Imbedded in it is the number "2", which is printed in standard shade number two. Reference black (standard shade number 10) is shown by the number "10" imbedded in standard shade number nine, the lower right circle. The background gray of the large center circle is standard shade number five, the approximate center of the gray-scale spectrum.

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[1] "Universally understood"is an engineering term meaning "likely to be intelligible to other engineers."

[2] For our purposes, the ingenious EIA test pattern is somewhat over-complicated.

3. The resolution chart is based on the simple Snellen Eye Chart. The use of such a chart to illustrate the resolution quality of TV hardware seems particularly appropriate for the following reasons:

   (a) It is a standardized image familiar to anyone who has had his eyes examined.

   (b) It is designed, after all, to check the resolution capability of the eye.

   (c) It provides a direct indication of the system's ability to reproduce readable print of various sizes. Lines of horizontal and vertical resolution may be subject to individual interpretation, but ITV systems must reproduce readable print.

   There is, of course, a correlation between reproducible type size and horizontal resolution as measured by EIA standards. Figure 7 shows this relationship.

   (d) Picture-to-snow is demonstrated by certain of the illustrations below.

   Figures 8 through 11, which are reproductions of our simplified test pattern as seen on a television screen, show various impairments caused by the television system.

   Figures 13 through 16 demonstrate picture-to-snow ratio. As indicated earlier, engineers measure this technically as video signal-to-noise ratio at the receiver input. Their unit of measure is the decibel (db). In the pictures below, the television systems were adjusted to provide signal-to-noise ratios of 40db, 35db, 25db, and 15db. A signal-to-noise ratio of 25db (Figure 15) is generally regarded by engineers as the poorest quality that most at-home viewers would tolerate before switching to another channel. In a later section we will demonstrate that even if you are willing to settle for a signal-to-noise ratio of 25db at the television set, you need a lot better than that at the front of the system.

In closing this brief tour, we don't want to leave the impression that these four picture characteristics are the only ones that matter. Systems also develop black streaking, white streaking, ghosting, and other problems. For now, however, we can leave these troubles to the engineers.

In a moment we'll proceed to some of the major building blocks of television systems. In order to keep communication flowing smoothly, however, we must pause briefly to discuss a few essential terms.

A FEW BASIC DEFINITIONS AND COMMENTS

It is not the purpose of this section to present a complete glossary of terms. These are available in many convenient references[1], and it is unnecessary to duplicate an exhaustive list here. Nevertheless, a few basic definitions and some short explanatory comments may make the rest of the book easier going.

Hertz - A unit of measure corresponding to "cycles per second." The term is frequently used with common prefixes to indicate larger units: kilohertz (kHz), 1000 cycles per second, megahertz (mHz), a million cycles per second; and gigahertz (gHz), a thousand million cycles per second.

Telecommunications - Literally, communications over distance. A general term which is becoming accepted to include all known forms of electronic communication, including television, radio, data transmission, telephone, teletype, etc.

Closed-circuit transmission system - A system of transmitting or distributing telecommunications information (for example, TV pictures and sound or computer data) over a wired system so that reception is limited to specific receivers connected to the system.

Open-circuit transmission system - A system of transmitting or distributing telecommunications information over a broad area through the use of radio[2] waves, so that the information can be picked up on any standard receiver.

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[1] Some standard references are· Lewis, Educational Television Guidebook and Kessler, Fundamentals of TV Systems

It is worth pointing out that the Federal Communications Commission does not officially employ the terms "closed-circuit" and "open-circuit in the Rules and Regulations. Furthermore, the Commission exercises no direct jurisdiction over most closed-circuit systems as defined above. FCC Rules and Regulations recognize two general categories of operation known as Broadcast and Fixed" service. The broadcast service is that described above as "open-circuit," while the fixed services include such categories as point-to-point microwave systems and other non-broadcast services. A fixed service of particular interest to education is:

ITFS - the Instructional Television Fixed Service. This is a television system which does not fit either the open-circuit or closed-circuit definition. It is properly described as a multiple-addressed fixed service, and it was established by the FCC in 1963 exclusively for educational use. Since these systems operate in the frequency range of 2500 mHz, they are also commonly known as 2500 megahertz (or megacycle) systems. ITFS provides qualified educational applicants with a group of up to four TV channels and also provides a degree of transmission privacy not possible in the broadcast service, since special receiving converters must be used at each receiving location. A complete description of this service may be found in the booklet ITFS: - What it is... How to Plan, which was produced cooperatively by a number of interested agencies. It is available through the National Education Association, 1201 Sixteenth Street N.W., Washington, D. C. 20036. A single copy is free to administrators through AASA.

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[2] The term radio is used here in the general sense to mean the the transmission of intelligence -- either audio or video -- through the use of electromagnetic radiations in space, without the use of wires or cables.

VHF - An abbreviation for Very High Frequency. As applied to television, VHF channels are those numbered 2 through 13. Channels 2 through 6 are the "low-band" VHF group, and channels 7 through 13 are "high-band." There is no channel 1.

UHF - An abbreviation for Ultra High Frequency. As applied to television the UHF channels range from Channel 14 through Channel 83.

It may be interesting to note that in the VHF channel group, channels 6 and 7 are adjacent numbers but not technically adjacent channels. The gap between Channel 6 and channel 7 contains all the FM broadcast channels, the aeronautical navigation and communications bands, and two-way communication services of various kinds. An even larger gap divides channel 13 and channel 14. These gaps or breaks in the TV assignment plan are responsible for significant differences in performance among groups of TV channels.

Microwave - A range in the frequency spectrum lying above 1000 mHz, commonly used for point-to-point communications through the use of highly directional transmitting and receiving antennas. For example, TV signals are commonly relayed from the station's studio to its remote transmitter site by microwave. These particular microwave units are known as STL (Studio-Transmitter Link) systems.

TV Translator - A relatively small, low-power, inexpensive device that receives a TV signal from a distant TV broadcasting station, automatically converts the signal to another TV channel, and then rebroadcasts it. In this way, the station's range is extended or shadow areas are filled in.

Cable Television - A method of delivering TV programs to homes, schools, classrooms, or other specific locations via cable from a central originating point. If this central point is a TV studio the cable system is generally regarded as a closed-circuit distribution system. If the central point is a master antenna system capable of receiving multiple programs simultaneously from distant broadcasting stations, the cable system is generally referred to as a CATV (Community Antenna TV) system. Smaller systems restricted to serving apartments or classrooms within one complex are known as MATV (Master Antenna TV).[1] The transmission cable, because of its design, is called coaxial.

Video tape recording and reproduction - A method of storing video and audio television signals directly on magnetic tape in a manner suitable for immediate playback as often as required. An additional unique feature is that the stored programs can be "erased" easily to permit repeated use of the magnetic tapes.

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[1] You may wish to consult also Through Cable to Classroom, available from The National Education Association.

Educational Television Station - A televison broadcasting station, either VHF or UHF, technically identical to a commercial television station but devoted exclusively to non-commercial educational programming on channels reserved by the FCC specifically for non-commercial educational use. The specific mission of such stations is to serve the instructional, cultural, and informational needs of the areas to which they are assigned. It is interesting to note that although certain channels were reserved in 1952 for educational use, there are no channels reserved for commercial use.

EIA - Electronics Industries Association. As the name implies, EIA is one of the major organizations of electronics industries. The association is important to our work because it has accepted the responsibility for establishing technical standards in many areas of communications and electronics, including radio and television. Some standards bear the imprint of EIA's earlier names: RETMA (Radio Electronics Manufacturers Association) and RMA (Radio Manufacturers Association).

Telecommunications - Literally, communications over distance. A general term which is becoming accepted to include all known forms of electronic communication, including televison, radio, data transmission, telephone, teletype, etc.

Broadcast Quality - A technical performance level meeting the minimum requirements for the broadcast services as set forth by the FCC in the Rules and Regulations.

This definition warrants some discussion in that it has become an object of abuse and misuse throughout the television industry.

First, it should be clearly recognized that FCC requirements or "FCC standards" are actually minimum requirements for the broadcast service and as such do not necessarily constitute the highest possible standards of good engineering practice. Consequently, literal compliance with the minimum standards as set forth in the Rules and Regulations does not insure an exemplary technical operation. One might paraphrase the foregoing statement by pointing out that merely keeping out of jail does not in itself constitute good citizenship. The fundamental point is that TV and radio equipment correctly classed as being of broadcast quality nevertheless exhibits a wide range of performance levels.

Furthermore, it should be recognized that a substantial portion of the FCC standards deal rather rigidly with requirements for the synchronizing signals, and they give considerably less attention to the requirements of the picture signal. This is understandable since the FCC is insistent that the shape, timing and temporal stability of these synchronizing signals be sufficiently uniform between different broadcasting stations so that the home receivers will display a picture without undue vertical "roll", horizontal "tearing", and "pairing" of the scanning lines.

The net consequence of this emphasis on the synchronizing signal is to insure that the average TV receiver is capable of displaying a stable picture, but the picture may not be worth watching because of impairments that are not treated in the rules. A typical - and appropriate - example of this kind of situation may be found in some of the helical-scan tape recorders offered to educators as low-cost substitutes for the more expensive quadruplex[1] machines which are almost invariably used in TV stations. Some of these helical-scan machines are offered as meeting FCC broadcast standards. This may lead the potential customer to the belief that these machines perform as well as the quadruplex machines.

Actually, this only means that the synchronizing signals meet the appropriate FCC standards. Furthermore, these minimum FCC standards are generally not achieved inherently in the machine itself but usually through the use of an auxiliary "black-box" device known as a processing amplifier which may cost a third as much as the video recorder itself. These devices perform the necessary improvements on the synchronizing signals with virtually no effect on that portion of the signal which influences the picture quality.

The matter of variations in performance levels of equipment will be discussed more completely in following chapters.

THE BUILDING BLOCKS OF A TELEVISION SYSTEM

Having rooted about in the elements of television engineering, we can now begin to put these elements together to form a complete system.

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[1] These standard broadcast recorders are called quadruplex because they have four rotating recording heads.

Figure 17 is a simplified flow diagram of a complete television system. As you see, the system is in three major parts: program orgination, transmission, and reception. Also, prominently indicated is the omnipresent videotape recorder. The following chapters of this book treat, in order, these major building blocks of the television system.

We are now past the thicket of general principles and basic elements and fundamental terms. We begin to see how practical, economical systems are put together.

CHAPTER IV

TV PRODUCTION SYSTEMS

The Concept of the Studio

A look at your home TV set will demonstrate that television production takes place in a variety of places: on football fields and city streets, at political conventions and beauty pageants, in classrooms and offices, and even in television studios.

When the production is successful, all of these places have certain important things in common:

1. There is enough light for the operation of the cameras.
2. There is a place to put cameras and microphones so that the action may be followed appropriately.
3. There is a place to put control equipment, and there is adequate electrical power.
4. Means are established so that the persons responsible can command the equipment with reasonable ease.

Other common characteristics could be found, but these will do for now. As one considers possible uses of his television system, he would do well to look over this list. Want to cover a professor's talk in a lecture hall? Is there enough light? Where will we put cameras and microphones? Where can we put the control equipment? Is there enough power in the building, or must we find a generator? How can we assure that cameras will see what needs to be seen, and that microphones will hear the important words?

These four requirements must be met whether the program is the most carefully prepared drama or snap coverage of civil strife.

And there are variations. For example: want to use television for teacher observation? In considering control, one may decide to use small cameras operated remotely, so that the hardware will be inconspicuous and there will be no human cameramen to distract the students. Or; Want to observe psychiatric interviews? Be certain that equipment chosen is sensitive enough to operate at normal light levels and that placement of microphones will not affect the patient's responses.

Or, to take a large leap: Want a place for the production of carefully prepared instructional materials? Television materials that really concentrate on bringing together the subject matter and the learner? Make no mistake about it: you need a television studio, and nothing less will do.

Basically, there are two kinds of television production. One fundamentally reports action as it happens; the other starts with the objective of communicating specific information, ideas, or attitudes, and the entire television experience is shaped toward those ends. Television that reports action is characterized by coverage of sports events, political conventions, parades, and such. The "shaped experience" is illustrated by television drama, commercials, newscasts, and the presentational varieties of instructional television. These are assembled in the studio.

The television studio is a place for the preparation of flexible magic. It may house a simple stand-up lecture or castles in Spain. It can show a piece of sculpture in the best lighting it will ever have. It can impart the dynamism of a string quartet doing justice to Haydn. A simple set and painstaking lighting help bring alive the actor's presence as he illustrates a point from great literature. The science teacher's demonstration is shot with carefully rehearsed cameras to keep interest at a peak and communicate the principle exactly as intended.

Learning is influenced by the space in which it occurs. With a proper studio, we may approach the instructional problem by asking "What should this experience accomplish?" Without it, we are back to using television merely to report what is in front of the camera. In many instructional situations, the result is a sort of public address system with pictures.

The studio meets those four requirements of adequate light, a place for cameras and microphones, a place for control equipment, and a capacity for control. But the studio pushes these requirements to logical conclusions. Not just enough light, but a precise amount of light exactly where it is needed. Not just a space in which to put cameras and microphones, but an area in which they can move, a space in which cameras can see and microphones can hear just what is intended. Not merely technical control, but a place in which many picture and sound sources can be orchestrated to do a carefully defined job and do it well. And finally, not just the ability to direct the use of hardware, but a facility in which a well-trained team can do its work.

If the foregoing rhetoric sounds a little purple, visit a commercial production house as it develops informational and attitudinal materials about a new brand of cigarette. See carefully researched instructional technique as it is applied to television production.

Needs, Objectives, and Studios

It is worth reiterating that many instructional television installations operate very well with no studio at all, and others are fully operational with a very rudimentary kind of studio space. We are simply revisiting the old questions of needs and objectives. If your production requirements are very modest, it is possible that a well-lighted classroom is all the "studio" you need.

A great many valid uses of television do not imply studio production in any form. But if your objectives do dictate a studio, and if your architect is not experienced in this specific design problem, insist on competent help. Television studio design is hardly the most complicated problem in modern architecture, but it offers an incredible number of traps for the unwary or uninitiated.

Requirements of Studio Design

What follows is not a discourse in how to design a studio. Rather, it is a list of some of the factors to be considered. It is frankly and deliberately written from the perspective of the television practitioner as he confronts the problems of instructional production.

1. Is there enough floor space? When a studio is smaller than 40 x 50 feet, its use is greatly restricted and its efficiency is seriously impaired. There are several reasons why this is so:

   (a) A typical simple instructional production requires one or two distinct playing areas for live action, one or two separate areas where graphics are shot, and ample room for camera movement among the areas.

   (b) In order to light a set properly, it must be several feet from the nearest studio wall. A small saving in construction cost is more than offset by the day-in, day-out delays and frustrations of attempting to light a studio that is too small.

   (c) If there is more than one set in a studio, each should be lighted so that no stray light spills onto other sets or onto studio walls.

   (d) Cameramen must concentrate on their shots, and not on studio traffic problems. Ample camera space represents money well spent.

2. Is the ceiling high enough? If the studio lighting grid is less than 14 feet from the floor, somebody should take a second look. Low ceilings cause virtually insurmountable lighting problems and there should be a reasonable amount of air space above the grid.

3. Is cabling for lights, cameras, and microphones designed so that the studio floor is cluttered as little as necessary?

4. Is there convenient access from the control room to the studio? Contrary to popular opinion, it's not really necessary for a television director to see the studio floor: the cameras are his eyes. But particularly in instructional production, there is frequent need for the director to move between the control room and the studio.

5. Is there adequate storage for pieces of sets, graphics, frequently used furniture, etc.? If you were to ask a hundred production people to name the most annoying flaw in their own studio's design, at least 90 of them would complain about storage.

6. How about outside access to the loading dock, the scene shop, the driveway, etc.? Ask your architect how he proposes to accommodate your need to drive a truck onto the studio floor. Are the studio doors high enough and wide enough to accommodate sets, furniture, vehicles, and all the bulky oddments that appear on television?

7. *Is the floor flat?* One of your production requirements is to allow cameras to move while on the air, and any imperfection in the floor is greatly magnified in a joggled picture. Most people believe that the best studio floor is smooth concrete. Some standard educational specifications specify asphalt tile, which is all right if several hundred pounds of camera or a couple of tons of automobile can roll over it without causing it to curl.

8. *Is the studio isolated from outside noises*, including the sounds from the control room and the whoosh of the air-conditioning system?

9. *Can the air conditioning system handle the load?* Television lights generate a lot of heat. And is the system designed so that the flow of air will not disturb the sets or cause false noises in the delicate innards of microphones?

10. *Are control room areas designed for efficient use of equipment?* Is equipment grouped for convenient coordination by technicians? And (since hardly any budget is big enough to buy everything at once) is there enough space to accommodate growth?

11. *Will control room air conditioning accommodate present and future equipment?* Although modern solid-state equipment runs much cooler than the older varieties, it is still true that the equipment needs the air conditioning even more than the humans do.

12. *Is the electronic maintenance facility reasonably convenient to the control rooms?* Breakdowns during production are

frustrating, time-consuming, and extremely expensive. An investment in maintenance convenience will pay off in cold cash.

Studio Equipment

It would be convenient for us and for you if we could say essentially, "Here is what goes into a television studio and this is what it costs." But there is an enormous variety of equipment, manufactured for a great range of applications. One instructional television facility may be equipped more expensively than the local commercial TV station; another may seem very spartan at first glance; and both may be properly equipped for their respective purposes.

Suppose that you have decided in a general way on the amount of equipment to be purchased: X cameras, Y microphones, Z lights; studio switching system; audio control; film projection and control facilities; video tape recorders. The range of available equipment is extremely great. It's necessary to be very precise about the intended uses of equipment: Armed only with quantitative information, two purchasers can order from identical shopping lists and one may spend fifteen times as much as the other.

Given full information about the respective intended uses of the two lists of equipment, it is still possible that two purchasers could buy the same quantity of equipment, that both of them could purchase wisely, and that one might spend ten times as much as the other.

In comparing cameras, or switchers, or tape recorders, or any of the other paraphernalia of the studio, one must acquaint himself with the strengths and limitations of a given piece of equipment, and one must understand the purposes for which it was designed. Part of this investigation must include quality of construction, performance reliability, ease of maintenance, and the ability and willingness of the vendor to provide effective field backup.

None of this is intended to make villains of the equipment manufacturers. Television equipment, like other consumer products, is designed and manufactured in response to indications of particular needs in particular marketing groups. If as an educator (operating on an educator's all-too-usual low budget) you express a demand for television equipment that has low cost, compact dimensions, few maintenance needs, and which may be operated by untrained personnel, manufacturers will try to respond. In meeting these demands, however, something has to give. The low price tag may bring with it low quality of performance. The simplicity of operation may also mean lack of flexibility. If on-the-job maintenance is not contemplated, the machine may be unduly difficult to repair at all.

Through it all, however, the manufacturers have presented to education a range of equipment that meets almost every need. One unhappy result is that this wide choice constitutes a veritable electronic jungle which complicates the selection process. All too often, therefore, equipment choices have been determined almost solely by the sales skill of the vendors, assisted by low price tags. The result has been the acquisition of equipment and "systems" with capabilities bearing little or no relationship to the educational task at hand.

It is difficult to quarrel with the desire to purchase anything at the lowest possible price. However, a more useful approach would be to study the educational problem and then select television equipment that has the features needed, skips the frills, and provides the capacity to grow.

The really significant purchasing criterion is not the price tag (large or small) of a given item, or even how "good" it is, but the ratio represented by capabilities received for the money spent. Admittedly, it is no easy task to decide how much a given characteristic is worth to you. But in trying to do so, you at least approach an objective appraisal of the merits and demerits of a particular item of equipment.

A short digression may be useful. One extremely common item of equipment is the television camera. The television camera is also the item available in perhaps the widest range of capabilities and cost. This was not always the case. Prior to the development of the low-cost vidicon TV camera pickup tube in 1950, most studio cameras employed the image orthicon pickup tube with the result that studio cameras of competitive manufacture exhibited similar characteristics and cost. Almost all TV pickup tubes used in film projection chains were iconoscopes. Life was relatively simple for the equipment purchaser.

Then came the vidicon tube, with its characteristics of initial low cost, long operating life, and low operating cost.

These factors triggered the introduction of the "industrial television" era, which created a new generation of shoe-box size television cameras intended for all sorts of surveillance applications in industry. In order to capitalize fully on the low cost of vidicon tubes in low-cost cameras, it was of course necessary to reduce the performance standards of the electronic circuitry and mechanical construction. This was a relatively simple matter, since the cameras were to be used exclusively in closed-circuit situations over which the FCC Rules and Regulations had no control. Furthermore, no standards of performance for these applications had even been considered.

The great success of these low-cost vidicon industrial cameras, costing less than a thousand dollars, spurred the development of the vidicon camera for use as the TV pickup unit in studio film projection chains. This development was particularly appropriate since:

1. the available iconoscope film chains were terrible, and
2. the main disadvantage of vidicon tubes, the need for relatively large amounts of light, could be overcome easily in projection systems.

At about this same time, educators were rapidly becoming aware of the potential of television as a modern educational tool. They created a demand for low-cost television equipment for experimental closed-circuit operations. Manufacturers took slightly improved versions of the industrial vidicon camera, gave them electronic view finders, and *voilà*! the market was served. It is fair to say that the availability of these second-generation vidicon cameras did much to stimulate the growth of educational television in the early fifties. As the educators recognized the need for higher technical quality, manufacturers responded with higher-quality cameras, selling at higher prices, until vidicon systems that met minimum FCC broadcast requirements became available.

Educators now had the option of choosing between the image orthicon cameras used by most commercial broadcasters and a vast array of vidicon cameras ranging from the cheapest industrial surveillance camera to a modern broadcast-type vidicon camera costing almost as much as its big-city image orthicon cousin. For the educator, the age of technological confusion was in full flower. Since that time, unhappily, things have only become worse.

The only way out of this thicket is to base decisions soundly on educational objectives, scrupulously matching the equipment to its intended use.

For example: vidicon cameras and image orthicon cameras are complementary, not competitive. They have their separate sets of advantages and limitations; in some ways, they are hardly comparable. Here are a few specifics:

a. Expensive image orthicon pickup tubes ($1000 to $1200 each) can be permanently damaged if pointed toward a high-intensity studio light. (Thus, inexperienced cameramen can be expensive).

b. Image orthicon cameras have a tendency to "burn" images into the photo emissive plate, and these burns may persist for some time. It is best not to use these cameras for prolonged looks at stationary scenes such as cards bearing sketches and lettering. Vidicon cameras don't have this problem.

c. Vidicon cameras exhibit "smearing" of moving highlights under lighting conditions that are less than optimum (and optimum is a lot of light). Thus, we can't use vidicon cameras for such things as indoor sports events unless we can light them adequately. Otherwise, the viewers may see the trajectory of the moving ball as a white streak.

d. Vidicon cameras are easier to operate than image orthicons, and by and large are somewhat more rugged.

e. Image orthicon tubes and vidicon tubes have somewhat different gray-scale response characteristics. Vidicon tubes actually produce a wider discernible range of grays. But most people like the relative "snap" and subjective clarity of the image orthicon picture, and they consider the vidicon picture to be somewhat soft and washed out.

f. A top-quality black-and-white image orthicon camera chain costs about $25,000. A top-quality studio vidicon camera chain costs about $15,000.

The cheapest industrial surveillance vidicon is about $295. On the other end of the scale, the more expensive color cameras cost upwards of $75,000.

g. Vidicon tubes cost less than half as much as image orthicon tubes, and they last several times as long.

Which one to choose? The decision must be based on educational objectives. The camera that is fine for one situation may be out of place in another for reasons that can't be resolved into good and bad. Within affluent commercial broadcasting, for example, the inexpensive vidicon is almost universally used in film chains. In that situation, the vidicon's advantages shine brightly and its limitations can easily be overcome.

With variations, the same story could be told about many other items of equipment. A switcher can be half a dozen pushbuttons or can be a console capable of myriad special effects in color. An audio control board may be a few switches and volume controls, or it may be a complete system, capable of reverberations and echoes and selective frequency enhancement. Lighting may be controlled by ordinary wall switches or by a complex system of dimmers, sub-mastered for various studio areas and capable of several preset evolutions. Depending on what you want to do, any of these choices may be correct.

And regardless of what you want to do, there are equipment salesmen ready to prove that their "complete systems" are an instant answer to your prayers. And so they may be, just as the latest medicine from a pharmaceutical house may be exactly what your ailment requires. In either case, it's best to make your purchase after expert advice.

CHAPTER V

TRANSMISSION SYSTEMS: GETTING THE PROGRAM FROM HERE TO THERE

As a practical matter, an educator transmits his ITV material by any of three means:

1. Open circuit, on braodcast stations;
2. Closed-circuit, on cable systems of various kinds;
3. The 2500 mHz Instructional Television Fixed Service.

The engineer might take a slightly different look at the alternatives. From his point of view, all known practical transmission systems may be initially classified either as radiation systems or as guided systems.

Radiation systems involve radiation of electromagnetic waves through space. In television, radiation systems include:

a. Broadcast (open circuit) over VHF stations (channels 2 through 13) or UHF stations (channels 14 through 83);
b. Microwave (highly directional point-to-point transmission),
c. 2500 mHz ITFS (multiple-address point-to-point).
d. Overhead satellite;
e. Laser communication beams, now under development.

Guided systems involve the use of conducting materials to guide the signal along a specific route. We usually think of cable in this connection, but technically there are other possibilities.

Having conveyed something of the scope of radiation and guided transmission systems, let's return to concentrate on those techniques most useful to the educator.

Choosing a transmission system takes us back once more to needs and goals. ETV stations, 2500 mHz ITFS systems, and cable systems are all very good answers, but to different questions.

Briefly:

ETV stations cover a large area with one channel. The addition of other channels depends on their availability and requires duplicate transmission facilities. ETV stations are intended to offer a diverse service to an entire region, and do not concentrate solely on instruction.

2500 mHz ITFS systems offer up to four channels of service at relatively low cost. They are reserved specifically for noncommercial instructional use. But they operate at low power and are intended to serve a relatively restricted area, such as a single school district or, at most, a small county.

Cable systems come in many sizes, shapes, and costs. One kind of cable system distributes programs within a building, and another -- the CATV system -- distributes service to many homes for a monthly fee. There is sometimes a question of whether a cable system or an ITFS system will be most useful or economical in a given situation.

Let's consider these three techniques in somewhat more detail.

Television Broadcasting Systems

It has been noted previously that broadcast stations are either VHF (channels 2 through 13) or UHF (channels 14 through 83). A number of channels have been reserved specifically for noncommercial educational use, and in a few areas of the country it is still possible to secure a non-reserved channel that is not otherwise spoken for. As a practical matter, most remaining channels -- except in certain sparsely settled areas -- are UHF.

It's easy to check on whether a channel reerved for education is available in your area. The official source of the information is the FCC table of assignments listed in Part 73. 606 of the FCC Rules and Regulations. Perhaps more convenient are several reference annuals such as the "Broadcasting Yearbook," published by "Broadcasting" magazine, and "Television Factbook." Either may be available at your public library.

If a noncommercial educational reservation does not exist, it is important to recognize that the FCC has provided machinery whereby one may petition to reserve other channels. The channels that are not reserved for education are not automatically reserved for commercial interests.

Furthermore, even if the allocations table shows no available channels in your area, an engineering study may reveal ways in which another channel may be "dropped in" by the Commission upon your demonstration of need.

But before we become bogged down in the mechanics of channel selection and in the arduous task of assembling an application for an ETV station, it will be well to explore the fact that an ETV station is more than an instructional device. It is charged with the responsibility of providing a full range of informational, cultural, and educational services to people in their homes. It is intended to serve education at all levels, its scope as broad as the scope of the problems and needs of the entire geographical area it covers.

Educational television stations, then, have a somewhat different mission than do installations which are purely for in-class instruction. An educational administrator who seeks to solve a primarily instructional problem must confront that fact carefully. Several school systems - that of Denver is a notable example - have accepted the challenge of full ETV station operation. If your study indicates that you may undertake that step, we can move on to other considerations.

A number of factors revolve around the VHF-UHF problem. Most of the established, popular, network commercial stations are VHF. Even though all sets manufactured since 1964 have been equipped to receive UHF, people have been in no great hurry to put up UHF antennas, and a good many people with relatively new sets are not even aware of the fact that they can receive UHF. One of the prevailing misconceptions is that some sort of adapter is needed to receive educational stations. Conversely, some struggling commercial UHF stations are constantly frustrated by the common belief that since they are UHF they must be educational. The situation is worsened by the fact that some set manufacturers have not been notably enthusiastic about including UHF capability in their low-cost receivers, and this apathy is often reflected in the quality of their UHF design.

Eventually, as more stations go on the air and as the audience becomes acquainted with services offered by UHF stations -- both commercial and educational -- this confusion will gradually go away. At the present time, however, the administrator who contemplates establishing an ETV broadcast station should find the answers to some specific questions, about which some comment will follow.

1. Is your area served by existing UHF stations, by VHF stations, or by a combination of both?

   If an area is already served effectively by one or more UHF stations, your potential audience members may already be accustomed to using the UHF band on their TV sets. But if the area has, say, one independent UHF station and a number of VHF stations (which probably have the network affiliations), UHF may still be a stranger in most homes.

   If the area is presently served only by VHF stations - and you contemplate adding a UHF educational station - you may be in for a frustrating and lonely time. You can have a gala inaugural broadcast, attended by all the right people, you can put on publicity campaigns that you can't afford; you can present programs that make you proud to be in television; and an overwhelming number of people still won't know you're there. A discouraging number of them won't even care.

2. If an existing service is provided primarily by VHF stations, how many receivers in the area are equipped for UHF?

   People who have bought television receivers since

1964 can hardly avoid having UHF, since manufacturers are now required to include UHF capability in their sets. Nevertheless, you will want to have some accurate idea of where the potential UHF audience is.

3. Even though a large number of UHF receivers may exist, how many are actually equipped with a UHF antenna?

Having UHF on your set and being able to receive UHF are two different matters. Your handsome new portable will have built-in-rabbit ears that are not connected to the set's UHF tuner. For UHF reception, there is a small wire loop that attaches to the set at the back -- if you didn't inadvertently throw it away or dismiss it because you didn't know what it was.

Even if a set is equipped with an indoor antenna, and even if you are not too far from the station's transmitter, the picture may be flawed by nearby buildings or hills. A proper outdoor antenna can help. UHF antennas are especially convenient to mount, because they are much smaller than those used for VHF.[1]

4. If the area is already served by a UHF station, would it be possible to construct the new educational transmitter on or near the premises of the existing UHF transmitter?

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[1] Antenna size is related to the size of the wave to be received. The higher the frequency, the shorter the wave. UHF waves, thus, are shorter than VHF, and UHF antennas are smaller.

Why should you locate your UHF transmitter on the same site as other UHF stations?

So that viewers at home can point their antennas in one direction and receive all available UHF channels. Such a cooperative arrangement usually benefits all concerned.

To conclude this discussion of the VHF-UHF problem, we should note that schools are hardly affected by it at all. Since most schools add television antennas, distribution systems, and receivers only with the advent of the educational television station, it's of no particular consequence whether the station is UHF or VHF.

To summarize, then:

1. Educational television stations technically are identical to any other television stations, operating either VHF or UHF on channels. Most new stations will be UHF, and this is a source of some practical frustration.

2. Educational television stations, unlike more specialized operations, have a responsibility to serve the diverse interests of an entire geographical region. Instruction is generally a major part of their task, but it is by no means the whole task.

3. Television stations operate at high power over a broad geographical area, with a service diameter commonly in excess of a hundred miles.

4. Television stations operate just one channel, while instructional loads and scheduling problems may make multi-channel capability an important factor.

Television Cable Systems

Within the scope of this book there are two kinds of cable systems for education. The one contemplated in this section is the city-wide or district-wide system of the sort that would be an alternative to broadcast or to 2500 mHz ITFS systems. The smaller cable systems, serving intra-building or intra-campus, will be discussed in Chapter VI.

Briefly, the characteristics of these larger cable transmission systems are:

(a) Since they invariably use the technique called RF (radio frequency) carrier transmission,[1] they are inherently multi-channel.

(b) The size of the system is limited by factors which have no bearing on the limitations of radiation systems.

(c) Since they don't depend on assignment of frequencies by the FCC, you can use as many channels as you can afford, with no limitations imposed by the lack of space in the electromagnetic spectrum.

One acquires a cable system in either of two ways:

1. Build, maintain, and operate your own, or
2. Lease service from the local phone company or

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1 more about this in Chapter VI

from another carrier such as a CATV company.

The major cost of constructing a television cable transmission system is (familiar story!) labor. Cable must be strung. Re-amplifiers must be installed every 1000 to 3000 feet, depending on the particular design.

As with power or phone lines, cable may be strung on poles or laid in underground systems. By and large, overhead cable costs less to install and underground cable costs less to maintain. Underground costs vary so much that no meaningful guidelines can be devised for the whole country. Some financial rules of thumb for aerial syatems will be discussed below.

The present state of the art limits the number of reamplifiers that may be installed on a cable. Depending on cable length and amplifier spacing, this number may be as few as 50, and it will seldom exceed 150. The result of these limitations is that cable runs are limited to about 30 miles.

This does not mean that you can't have an installation that extends more than 30 miles, but only that the system's originating point should be within 30 cable miles of any particular destination. In larger systems, the originating point is placed somewhere near the center of the service area so that greater reach may be achieved. Even in smaller systems, incidentally, it is still wise to place the origination point near the middle, since shorter cable runs mean less cost and higher performance.

The costs of overhead aerial cable systems -- at least those of reasonably large size -- are generally proportional to cable mileage. A good guess of construction costs for a user-owned system is $4,000 per cable mile. This takes into account the individual costs of cable, messenger cable, fittings, amplifiers, new construction, labor costs, etc. The actual range of costs is likely to be $3000 to $5000, with $4000 as a reasonable nationwide average at the time of this writing.

This cost formula assumes the use of existing utility poles (power or telephone) as cable supports. Commercial CATV organizations usually pay a rental fee of $150 to $200 per year per mile of pole supports. Since the poles in question are primarily for public utility purposes, it is probable that pole space for schools could be had for a very low rate, or even free.

The annual maintenance and operating cost of a school-owned cable system could be expected to range from as low as five percent to as high as ten percent of the initial capital outlay. Thus the complete cost formula becomes:

$$\text{Total Cost} = N4000 + NM400 + NM200$$

where N is the number of cable miles and M is the number of years.

Lease Costs for Equivalent Transmission Service

As indicated earlier, equivalent cable transmission service may be leased from the local telephone company or perhaps from such firms as CATV systems. Since the leasing rates charged by the phone companies are regulated by state utility commissions, the local phone company is your best source for information applicable to your specific area. However, rate structures are sufficiently uniform across the United States that a reasonably valid cost equation may be formulated.

Lease costs are based on:

1. Number of channels
2. Number of cable miles
3. Recurrent monthly lease charges
4. Non-recurring initial channel charge and school connection charges.

Thus, a leased system involves only a slight capital outlay and no periodic maintenance and operating costs. One regular bill pays for the entire transmission operation.

A direct cost comparison between a school-owned system and a leased system in not entirely practical, since the cable installation is inherently multi-channel although the "equivalent" leased service is dependent on the number of channels ordered. Recognizing that some sort of comparison is necessary, however, (particularly in the light of the fact that we must subsequently compare the costs of cable and ITFS) we offer the following equation for estimating annual lease costs from the telephone company:

$$\text{ANNUAL COST} = N1248 + p15$$

where N equals the number of airline miles from the origination point to the most remote destination point, and p is equal to the number of schools served by the leased service. A four-channel leased service is assumed. In the first year an additional amount of $1560 should be added to the estimate because of one-time construction charges.

Application of this cost formula is valid only within the local exchange area of the telephone company involved.

A final point regarding either school-owned systems or leased cable facilities: these transmission systems offer distinct technical advantages -- and perhaps economic advantages too -- when the problem is to cover a relatively small area characterized by rugged terrain. Such terrain may create severe propagation problems for broadcast or ITFS systems, and these factors may offset the relatively high cost of cable.

This is but another indication of the fact that the various transmission systems discussed in this chapter are not competitive or "equal alternative" systems that can be evaluated by studying price tags alone.

From time to time, possibilities are raised about the use of ordinary CATV systems as a version of a cable transmission system for schools. CATV systems commonly provide free service to schools; that is, they provide their regular service to schools at no charge. This regular service consists of a single connection which provides all channels -- commercial and educational -- carried by your local CATV system. Distribution of the service within the school, reasonably enough, is usually the school's problem.

In addition, some CATV systems provide an empty channel so that schools may distribute educational materials.

The availability of CATV service at the school is clearly a useful gift, particularly in fringe areas. There are, however, at least two matters that may be overlooked:

A. As noted above, distribution of the signal within the school is probably still your problem. Without an adequate distribution system, the generous gift of the CATV system doesn't do you much good.

B. Not all CATV systems provide really adequate signal strength. There are many instances when it would be simpler and better for you simply to put an antenna on the roof.

In examining the possibility of a "private" CATV channel for school use, other factors should be considered as well:

1. Does the franchise area of the CATV system cover the district, or will certain schools lie outside the coverage pattern?

2. The free channel is probably a spare, offered on a "space-available"basis. As the cable company grows up, will the channel still be available to you? Free?

3. It is probably your problem to deliver your television signal to the "head-end" equipment of the CATV system. How will you get it there?

In spite of the questions raised above, the fact remains that CATV systems are growing rapidly in coverage, technical competence, financial strength, and management sophistication. They are rendering valuable service to many schools. They will assume an ever-increasing role in the American communications complex, and you should not dismiss them lightly as you make your ITV plans.

The Instructional Television Fixed Service

These 2500 mHz systems have developed by leaps and bounds since the service was created by the FCC in 1963. Their characteristics are as follows:

1. Multi-channel capability
2. Point-to-point radiated transmission from a central location to several schools.
3. Low power for restricted coverage.

In a sense, ITFS borrows from broadcasting and from cable services. It uses "broadcast"-type radiation techniques, but at low power. Licensees may secure up to four channels from the FCC. The signals may not be received on ordinary TV sets without ITFS converters, and so some privacy is assured. Like cable systems, they are intended for relatively small areas.

It may be useful to conduct a small foray into the mechanics of ITFS transmission.

One of the central facts of ITFS is low power. While a UHF educational TV station may radiate upwards of a million watts of power, ITFS transmitters are held to ten watts. This fact is not necessarily a drawback. The ten-watt power limitation, combined with extremely sharp line-of-sight transmission characteristics, means that ITFS systems can be controlled very precisely. Another system using the same channel group can operate without interference only 15 or 20 miles away.

The reach of the system can be predicted quite accurately.

An elevated transmitting antenna will reach a distance in statute miles that is about 40% greater than the square root of the elevation in feet above the terrain. For example, an antenna 200 feet high will provide a line-of-sight horizon distance of 14.14 (the square root of 200) times 1.4, or approximately 20 miles. Beyond the horizon, the signal drops off very rapidly.

At this point it might be well to assess one of the major problems facing the decision-maker when considering an ITFS system to meet his coverage needs. This problem is rooted in the expansive coverage claims made by some proponents. In analyzing these claims, it must be recognized that television signals weaken gradually with distance, and thus the quality of the picture on the receiver deteriorates gradually also. The useful service range of any TV transmission system, then, depends on what you consider to be acceptable quality. Recall Chapter III what picture-to-snow ratio are you willing to accept? If you insist on relatively high standards for classroom reception, you may find that those ebulliently proclaimed service areas shrink drastically.

Similarly, suspiciously large projected service areas can sometimes be traced to the designs of engineering planners who call for impractically large parabolic receiving antennas placed at the top of absurdly tall towers in order to overcome losses from earth curvature, tall trees, hills, and buildings along the path between the transmitter and the receiving site. Terrain problems, incidentally, are particularly frustrating to

ITFS planners. The high frequencies used in these systems have even less "bend" than ordinary television. Hills, buildings, and groves of trees cause sharp shadows in ITFS coverage. Design ingenuity can overcome some of these troubles, but they can never be ignored.

In addition to the multi-channel availability and the essentially "tailor-made" nature of ITFS systems, one of the most attractive features is the cost. As in many areas of engineering, it is possible, with fingers crossed, to give some reasonably accurate estimates.

The following formula, carefully applied, will yield a good guess as to your likely costs:

Cost in dollars = $A + mB = nC$

where: A = cost of the first ITFS transmitter complete with transmitting antenna plus usual fittings, at $15,000.

B = cost of additional (up to 3) transmitters for desired additional ITFS channels, plus usual fittings, at $10,000.

C = cost of each school's receiving installation at $1500 each, consisting of one four-foot parabolic antenna and down converter with 20-foot antenna support.

m - number of additional ITFS channels.

n = number of school receiving locations.

Not included in the above estimates are:

a. Transmitting antenna supporting tower at $30/ft. Thus a 200-foot guyed tower costs $6000.

b. Transmitting plant transmission line/wave guide at $15/ft. Thus a 200-foot run costs $3000.

c. Antenna supports higher than 20 feet at school locations.

d. Transmitter building, if one is required.

e. Land areas to accommodate transmitter building and guyed tower, if this must be acquired.

The average annual maintenance cost equals about 10 percent of capital outlay.

Comparison of System Costs

It is clearly necessary for us to compare as well as we can the relative costs of different transmission systems.

Any such exercise must begin with the ground rule "Other things being equal ..." in spite of the fact that they never are. Our attempt here is to make things as equal as possible by comparing costs as applied to one carefully defined school district.

With geometric precision not found in real life, our model consists of a school district in which 32 schools are uniformly distributed along eight radials from a central origination point. This model is shown as Figure 23.

In order to make any sense at all, we must dismiss the broadcast system from our comparison. There are a number of reasons for this. First, the broadcast system is intended to serve a relatively huge geographical area. Second, it is essentially a one-channel system unless we are fortunate enough to have another channel available and virtually duplicate the transmission hardware. The cable and ITFS systems are functionally similar enough to compare, but the broadcast station is a wholly different animal.

To be compared, then, are a school-owned cable transmission system, a four-channel leased cable system, and a four-channel ITFS system. To apply the salient formulas from previous paragraphs to our present idealized model, we have:

For the school-owned cable transmission system:

Total cost - $N4000 + NM400 + NM200$.

For the four-channel leased cable service:

Total cost $= 1560 + p15 = NM1248$.

For the four-channel ITFS system:[1]

Total cost $= 45{,}000 + p1500 + M(4500 + p150)$,
where N is the number of miles, M the number of years, and p the number of school locations.

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[1] Not included in the ITFS formula is the cost of transmitting tower, wave guide run, receiving antenna supports in excess of 20 feet, and buildings and land. These are all highly individual variables, since the existence of one centrally located tall building will minimize them all.

The values for N and p in this idealized system are:

N = 160 miles.

p = 32 schools.

If we work out the equations and plot the results for a ten-year period, we find the rather dramatic results shown in Figure 24.

Please bear in mind that these results are for one single model system, and that for the sake of comparison, we have pruned away differences as much as possible. Thus, our formulas ignore the fact that, for example, an owned cable system could be designed to provide transmission from schools as well as to them, and that such systems could carry other services in addition to television. These services might include administrative information in hard-copy form, feedback from classes to the TV studio, computer signals, or any of several other services.

CHAPTER VI

DELIVERY TO THE CLASSROOM: TELEVISION RECEPTION FACILITIES

We have previously described the three major segments of the television system as Origination, Transmission, and Reception. This chapter discusses the last of these, without which the other two make no difference at all.

The importance of reception facilities is worth emphasizing, since they are so often overlooked. Since almost everybody has a TV set at home, reception is easy to take for granted.

It is useful to subdivide the reception process into three distinct elements. These are:

a. The receiving antenna system;
b. The in-school cable distribution system;
c. The television image display system, which is usually (but not always) a standard TV set.

The antenna system

All too often the humble antenna is ignored or simply taken for granted. But this seemingly simple structure of lightweight tubing and wire is enormously important. It does more than simply trap the signal and direct it to the TV set.

Particularly in areas of strong TV signals, it is assumed that simple rabbit ears will be enough. And from a purely "signal-capturing" standpoint, the assumption may well be correct. Unfortunately, this is not the whole story. In urban areas and mountainous regions, viewers are troubled by ghosts - multiple TV images caused by reflected signals that arrive at somewhat different angles from the basic transmission.

Ghosting may in fact be a problem even when the ghost is not readily visible. A ghost almost too small to notice can cause a serious drop in resolution. You may not identify the problem as ghosting, but you will know that the quality is not what it should be.

Since the signals that cause ghosting arrive at different angles from the basic transmission, the solution to the problem is the use of a highly directional antenna. This antenna can be carefully oriented toward the stronger direct signal to accentuate the positive (the sharp, high-resolution picture) and eliminate the negative (the ghost).

One of the most effective keys to good reception then, is an antenna that is well chosen, carefully mounted, and kept in good condition.

The Preamplifier - Outside antenna systems which operate in fringe reception areas frequently need a preamplifier. The preamplifiers are normally mounted immediately adjacent to the antenna, particularly if the antenna lead-in is more than about 75 feet long. The reason for the awkward location is that the antenna lead-in wire seriously weakens the signal by the time it gets to the receiver, The idea, then, is to boost the signal enough that it can survive the trip and arrive at the receiver sufficiently strong to do the job.

A word of caution about pre-amplifiers: if they are of inferior quality, or if they are not working well, they are literally worse than none at all. This is particularly true when receiving UHF signals.

The Channel Converter

Channel converters (sometimes just called converters) are used quite frequently for UHF reception and always with 2500 mHz ITFS systems. As their name implies, these devices convert an incoming signal from one channel to another. Converters are always located next to the antenna so that the UHF or ITFS channels are converted to the lower VHF channels immediately, before the signal is sent down the antenna transmission line. These lead-in lines almost always exhibit extremely great losses at the frequencies of UHF broadcast stations or ITFS transmissions.

One of the things that converters must do is to generate a very stable signal for conversion purposes. If this function is to be accomplished, the converter must be designed, built, and installed in such a way that it will withstand environmental extremes. Otherwise, the converted signal will be unstable when it appears on the VHF channels of classroom receivers, and teachers all along the system will distract students while they fine-tune their classroom sets.

The in-school cable distribution system

The antenna captures the television signal and, perhaps in association with the hardware noted above, delivers it to the input of the local distribution system. This system takes the TV signals to classrooms or other designated points.

Television cable distribution systems as they are discussed in this section are different from the television cable transmission systems which were considered in Chapter V. These distribution systems are much smaller. Trunk lines extend less than two thousand feet and thus do not generally employ the re-amplifiers used in transmission systems. The big transmission systems, you will recall, may have trunk lines as long as 30 miles, and so frequent re-amplification is essential.

Technically, cable distribution systems fall into one of two categories:

a. Direct video systems, or

b. Modulated RF systems[1].

Direct video distribution systems

Television cable distribution systems of the direct video type are designed to distribute the video picture signal and its synchronizing pulses in much the same way that signals are routed within large TV production centers. Coaxial cables in these systems act almost like hoses connecting one picture source to one classroom position. These systems can handle only one video signal at a time and require the use of a separate line to carry the sound. Switching between programs is done at a central place with a TV audio/video switcher.

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[1] The cable transmission systems, you may remember, are all of this sort.

One of the most important restrictions of direct video systems is that they are limited to trunk-line lengths of not much over 1500 feet unless elaborate equalizers are installed at frequent intervals to avoid losses in high-frequency response and hence a loss of detail in the picture monitor.

Direct video systems usually don't use ordinary TV sets in classrooms, but rather make use of monitors like those used in TV control rooms. Sound is heard through auxiliary speaker systems.

It will be no surprise, then, to learn that a direct video system, well designed and properly installed, is capable of much higher picture and sound quality than you receive at home.

A typical configuration for a direct video distribution system is shown in Figure 25. Note that the spoke configuration minimizes trunk-line lengths, so that they may be kept well within the limitation of 1500 to 2000 feet.

The characteristics of direct video distribution systems may be summarized as follows:

1. Provides the highest distribution quality now attainable.

2. Requires the use of studio-type video monitors[1] for classroom display. These also contribute to the high overall quality.

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[1] So-called "jeeped" television receivers have been used in place of the more expensive monitors. This is not recommended as it results in inferior performance which is not consistent with the quality capability (and the cost) of a direct video distribution system.

3. Subject to technical problems such as interference from power distribution facilities. This is particularly true on long cable runs.

4. Requires separate audio distribution lines and classroom speaker systems to distribute the sound.

5. Direct local program selection in the classroom is not possible unless additional coaxial cables are provided at additional expense. Switching between programs is done centrally by pre-arranged schedule or by request.

Direct video systems are generally employed only in those applications where the distribution system is confined to one building and where the requirement for the highest possible quality justifies the additional cost.

Modulated RF distribution systems

Modulated RF distribution systems make use of a head-end device known as an audio-video Radio Frequency modulator. These modulators are essentially ultra-low power VHF television transmitters. They are about the size of a shoe box, and they deliver an output power of no more than a hundredth of a watt. This low power is applied directly to the cable distribution system for distribution to classrooms on any convenient VHF channel. Since the sound and picture are combined by the modulator to form a standard VHF television signal, conventional TV receivers may be used in the classroom with the VHF channel selector set to the appropriate channel. Present technology permits "stacking and distributing up to 12 channels.

No FCC license is required to operate these miniature transmitters, since the signal is delivered to classrooms in the confines of a shielded cable, and no significant radiation takes place.

The configuration of RF distribution systems is generally quite different from the direct video designs. The RF cable systems are characterized by spur lines which "loop through" a group of classrooms, using less cable (and thus less money) than direct video systems. These RF systems may be regarded as miniature CATV systems, serving rooms within one building or perhaps serving several building in a complex. Figure 26 shows a typical configuration for an RF distribution system.

It should be noted that "off-air" programs from receivable TV stations may be applied directly to the distribution system through a head-end amplifier in order to provide the proper input level to the cable system. Occasionally, a channel converter is used in such applications either to convert a UHF station to a VHF distribution channel, or to shift a station from one VHF channel to another in order to minimize interference problems.

Although most RF distribution systems are restricted to the 12 VHF channels, a great deal of development is taking place with new head-end equipment and cables, so that economical distribution will be possible eventually on all UHF channels as well as the VHF channels.

The important characteristics of modulated RF distribution systems may be summarized as follows.

1. RF distribution systems are generallyless costly than direct video systems.
2. RF systems when used with their natural "partners in crime," standard VHF television receivers, do not provide the picture and sound quality that one can expect from direct video systems.
3. Like its big brother, the CATV system, the RF distribution system has a multi-channel capability and does not require separate audio lines.
4. There is no central switching system. Available programs may be selected in the classroom directly by the teacher.
5. RF systems may be designed to permit the distribution of programs that are originated from classrooms within the system.

Modulated RF distribution systems are generally employed in those applications where the receiving points (such as classrooms) are distributed over a rather large area, such as a major building or between buildings on a campus, and where a degree of picture resolution and sound quality may be sacrificed in the interest of economy.

Television Image Display Devices

The most familiar television image display device is the TV set in your home. Lest you think we have merely adopted a precious name for the familiar telly, however, we should explain that TV is seen via a number of devices, some of which only vaguely resemble the typical television set.

For purposes of this discussion, we have divided image display devices into categories, as follows. There is Direct View equipment and Projection equipment.

As the names imply, direct view hardware displays the television image directly on a TV screen; your home TV set is a direct view device. Projection equipment receives the image and projects it, rather like an all-electronic movie projector, on an ordinary movie screen.

Within these categories we have some subtypes.

Direct view equipment includes video monitors (usually used with the direct video distribution systems described above) and RF monitors/receivers (essentially ordinary TV sets).

Projection equipment is subdivided into those using a direct light system and those using modulated light. By and large, the former are cheaper and the latter are better, and we shall discuss both shortly.

Video Monitors

Direct view video monitors exhibit the three following general characteristics:

1. Single-channel video input without channel selector.
2. High horizontal resolution capability (600 to 800 lines).
3. Separate audio system required.

Video monitors are normally used in television production studios and with high-resolution single-channel video distribution systems where image detail and audio quality cannot be sacrificed in the interest of economy.[1] In addition to video monitors used in conjunction with a video distribution system, the installation system must also include a separate audio cable paralleling the coaxial video cable system. Direct view video monitors with 21" or 23" screens suitable for classroom use cost in the neighborhood of $500.00.

RF MONITORS/RECEIVERS

Direct view RF monitors/receivers exhibit the following general characteristics:

1. Multiple-channel RF input with channel selector
2. Limited horizontal resolution (250 to 300 lines)
3. Integral audio system.

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[1] For observation of surgery in teaching hospitals, for example.

RF monitors/receivers are, of course, nothing more than standard television receivers which are always used with RF distribution systems. Such receivers have standard channel dials which may be used to select any standard VHF or UHF signal which is available from an antenna system or a closed-circuit RF cable distribution system.

In some applications, the audio systems which are built into standard TV receivers may not be adequate to provide sufficient volume without excessive distortion. This disadvantage and the 200 to 300 line horizontal resolution limitation are the chief factors which limit the use of RF receivers as classroom image display devices. Of course these disadvantages are somewhat offset by the low cost of such receivers which range from $125 to $200 for a 23" screen.

Although RF receivers are, in general, not capable of accepting a direct video-signal input, they can be readily modified in the field to provide this feature. Such modifications are known as "jeeping."[1]

A number of television image display devices, which have been specifically designed for classroom use, are available commercially with video as well as RF inputs and a selector switch to permit operation as either a video monitor or RF receiver. The overall quality of these receivers is better than the average TV receivers marketed for general consumer use although they are not considered to be as good as professional video monitors.

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[1] But we don't recommend it, since quality suffers. See the previous section on distribution systems.

One of the principal advantages of direct-view monitors of either the video or RF type is that the light intensity -- or average picture bightness - does not vary significantly with the viewing angle; i.e., the angle of viewing with respect to a line perpendicular to the center of the screen. On the other side of the ledger, the maximum practical screen size is 27-inches measured diagonally. Most RF monitors/receivers intended for classroom use are either the 21 or 23" size rather than the larger 27-inch size which generally require more maintenance and picture tubes which are more expensive.

Direct-Light television projection systems employ a small high-voltage television display tube which develops a relatively small but very bright image which is projected onto a large motion-picture type screen by means of suitable optics.

The most common and inexpensive type of television picture projection system employs what is known as the Schmidt optical system in combination with a small (5") high-intensity picture tube as shown in Figure 27.

A very high-intensity television image appears on the face of the projection tube just as it would on a television set. The Schmidt optical system (the spherical mirror and the correcting lens) reverses the direction of the light rays to form the projected image on the screen. The barrel serves to provide mechanical support for the projection tube and lens system as well as protection against soft X rays emanating from the front of the projection tube face.

Projectors of this type throw" an image on a standard motion-picture screen ranging from 6' x 8' to 20' x 15'. The screen is normally placed at a distance of from 15 to 35 feet from the projector. Either front or rear screen projection may be used with the appropriate screen.

The brilliancy of the projected image is considerably less than a typical 16 mm motion picture (particularly for the larger 20' x 15' image) since the total light available for projection is limited by the maximum brilliancy of the image on the face of the television projection tube. The problem of low image brightness is usually minimized by locating the screen in a dark area to minimize the effects of the ambient light striking the screen.

Notwithstanding the problem of low picture brilliancy - and sometimes poor picture detail - the Schmidt optics projector provides reasonably good overall results at a comparatively low cost of about $3,600.

Schmidt optics projection systems are generally used in small auditoriums or large classrooms seating 50 or more when multiple small-screen direct-view monitor/receivers are not desirable and where quality in terms of picture brilliancy, picture distortion, and resolution can be sacrificed in favor of a large-screen display.

It should be borne in mind during the planning stages that almost all such projectors produce soft X rays because of the high electron beam accelerating voltages (40 to 50 thousand volts) which are employed. Therefore, if the purchase of such projectors is contemplated, the degree and effectiveness of x-ray shielding built into the projector housing should be carefully considered.

Modulated-Light Television Projection Systems

There is a general agreement among authorities that any television projection system capable of providing a large image of adequate brightness must be equipped with a constant high-intensity light source such as an incandescent electric lamp or a gas-filled electric light. However, the use of a constant high-intensity light source requires the use of a "light valve", or light modulator, to permit varying the intensity of the constant light source under the influence of the video signal.

The Eidophor television projector, developed in Switzerland, utilizes a xenon arc operating in a quartz glass envelope under a pressure of 20 atmospheres as a high-intensity light source and a unique light modulator using the "control-layer" process. The control-layer process of light intensity control, or modulation, was developed in 1939 by Dr. Fritz Fischer, Professor of Applied Physics of the Swiss Federal Institute of Technology in Zurich, Switzerland.

The control-layer light modulator consists of a concave mirror coated with a thin oil film (about .1 mm. in thickness) which "wrinkles" under the influence of a scanning electron beam which is in turn controlled by the video signal. As the oil surface wrinkles, its reflectivity varies, thus obtaining different intensities of the reflected light originating from the fixed high-intensity xenon light source. The electron beam assembly is identical to that used in a direct-view monitor and is enclosed in a vacuum chamber with the oil-coated concave mirror.

The fundamental elements of an Eidophor projector and how they are related are illustrated in Figure 28. A sketch of the projector assembly is shown in Figure 29.

The Eidophor is regarded as a television projector which provides by far the brightest television image possible with the least geometric picture distortion. However, the Eidophor is relatively expensive, costing in the neighborhood of $50,000.

The General Electric Company in the spring of 1968 announced a modulated-light television projector selling for approximately $35,000 using a "light-valve" to vary the light intensity under the influence of the video signal.

Modulated-light television projectors are used in large auditoriums in applications where bright pictures with good resolution and low geometric picture distortion are considerably more important than the cost of the projector. The modulated-light type of television projectors may be used for either front or rear-screen projection and is the only known type of projector which produces large-screen television images comparable in quality to a good motion-picture projector.

CHAPTER VII

THE MARVELOUS HEADACHE: TELEVISION RECORDERS

Recorders in Production and Distribution

If, in an especially black moment, you ever decide to select one item and heap upon it all the blame for the development of instructional television, the object of your wrath should be the television recorder. In an ever-increasing number of ITV installations, the critical item is the tape recorder. If a practical, flexible recording technique had not been devised, it is very likely that all the other TV gadgetry combined would have had a nearly imperceptible impact on instructional practice.

The tape recorder is a tool both of production and distribuiton. In the overwhelming majority of cases, material to be televised is assembled on tape and later played back. The tape recorder provides:

... Quality control

If the production effort doesn't succeed, try and try again.

... Multiple uses

The completed production effort can be played to different classes at different times, and it can be saved for use in subsequent semesters.

... A Medium of Exchange

Programs can be swapped with other centers or placed in distribution through regional or national tape libraries.

... A Time Machine

The tape recorder is a time machine accommodating individual schedules. It permits us to revisit events.

... A Mirror

It enables a teacher to look at his own teaching for self-evaluation. Similarly, students of (for example) physical education or speech can study their own performance.

The tape recorder, then, is an instrument both of production and of distribution, related to the studio, the transmission system, the school, and the classroom. In its several manifestations, the recorder is found in the largest ETV station and in the one-school installation. The tape recorder is ITV's keystone development.

As is the case with other items, there are various tape recorders for various jobs, and they come in various prices. As we shall see shortly, the range in both quality and price is staggering. However, the most difficult problems are not really those of cost or quality, but the struggle for compatibility.

Since the use of these machines is so pervasive, and since it is simply common sense to share high-quality materials, it is virtually essential that your tapes can be played on your neighbor's machine, and vice-versa. The rational man is distressed, then, to find that there are more than a dozen small television tape recorders on the market, and they operate on such a jumble of technical standards that generally speaking each machine only "understands" tapes produced on machines of the same brand. This gloomy factor has been the cause of innumerable studies and assorted pressure plays, the intent of which has been to get some uniformity from manufacturers. These efforts have not been noticeably successful.

Video Recording on Magnetic Tape: A Short Introduction

The enormously important gadget commonly called a videotape recorder[1] was introduced to the broadcasting industry in 1956 by the Ampex Corporation. Since that time the idea has spawned recorders of many sizes, types, orders of complexity, price ranges, and quality standards.

Magnetic tape recording is the only practical technique available for storing television signals directly in a manner suitable for immediate playback. Thus the videotape recorder accomplishes for television the same function that audio tape recorders accomplish for radio and recordings. The same basic principles of magnetic recording are used in video and audio, but recording video is obviously a more difficult and more expensive proposition.

While the variety of hardware is great, and although the range of price seems preposterous at first glance, it is not difficult for the non-engineer to absorb enough fundamental

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[1] The term Videotape is a trade mark of the Ampex Corporation. In a lower case rendition it has become a generic term along with kleenex and scotch tape.

"common denominator" performance characteristics to find his way out of the wilderness.

Consider the ordinary audio tape recorder. Given the relatively modest range of frequencies used in recording sound excellent results are possible if we pull a quarter-inch-wide tape past a stationary magnetic recording head at a speed of 7 1/2 inches per second. The result is a single long recording track laid down along the length of the tape. A really excellent machine can reproduce frequencies of 20,000 Hz by this method.

This relatively simple technique introduces one of the most fundamental concepts in electronic recording. This concept is "writing speed," simply the relative velocity between the recording head and the recording medium. In our audio tape example, the writing speed is 7 1/2 inches per second, the speed at which the tape is pulled past a stationary head. It would make no difference to the process, of course, if the recording head moved past the tape. It's just mechanically more sensible to move the tape.

Now consider the writing speed requirements for recording television signals. Where the audio recorder had to handle 20,000 Hz (20 kHz), a video recorder has to have an upper frequency response of about four million Hz (4mHz). This requires a writing speed at least 200 times greater, since four mHz is 200 times larger than 20 kHz. Thus the writing speed requirement for high-quality video is 200 times 7 1/2 inches per second, or 1500 ips.

Imagine trying to move tape past a stationary head at 1500 ips, or roughly 90 miles per hour. We would need 1,350,000 feet of tape for a 15-minute program. The problems of tape flutter and stretch would be enormous, and the device would need precision brakes that put Mercedes Benz to shame.

Quadruplex Recording

The practical answer turned out to be a method whereby both tape and head (or heads) move, in order to achieve the necessary writing speed with a minimum length of tape moving at manageable speeds. Figure 30 illustrates how the high writing speed was achieved with a slowly moving tape two inches wide. Note that the task of scanning the tape -- or laying down the magnetic tracks -- is shared by four heads equally spaced around a high-speed rotating wheel whose circumference is four times the width of the tape. The tape is moved only fast enough to separate the successive magnetic tracks laid down by the rotating heads. The result is a set of magnetic tracks almost perpendicular or transverse to the direction of tape motion as shown in Figure 31.

This method of achieving a high writing speed was named "quadruplex" after the number of heads used. However, "transverse track" could have been used just as well to distinguish the method from the longitudinal track of audio recording.

In addition to the video tracks, it is also necessary to record a conventional longitudinal audio track and a control track, essentially "electronic sprocket holes" to insure that the playback head scans the recorded video tracks precisely.

Slant-Track Recording

The new generation of lower-cost, relatively lower performance, more-or-less portable video tape recorders make use of a somewhat different scanning process. These machines lay down relatively long slanted tracks rather than nearly perpendicular transverse tracks. The key to the technique is a rather large scanning drum containing one or two magnetic heads. The tape is wrapped 360 degrees around this drum in helical fashion, as shown in Figures 33 and 34.

Once again, the tape is moved just fast enough to separate the successive slanted tracks, and the head (or heads) rotate on a high-speed disc inside the drum. Virtually all of these machines have chosen a combination of tape width, number of heads, head speed, and tape speed so that the time duration of each slant track is exactly equal to one television field (252.5 horizontal lines). It will be seen shortly that this characteristic provides slant-track machines with one unique capability. The process also has some drawbacks, as will be seen.

A high writing speed, then, may be achieved in various ways. The basic point is that it must be achieved if the machine is going to record enough information for a high-resolution television picture.

Of equal significance as a measure of performance is the video signal-to-noise ratio which provides a given "picture-to-snow" ratio of the reproduced television image. The video signal-to-noise ratio is established largely by the width of the recorded magnetic track.

To Review:

Good picture resolution is achieved through high writing speeds; good picture-to-snow ratio is achieved by relatively wide recording track. These facts have some very practical implications when one is shopping for hardware. You rarely get something for nothing; Mother Nature is an accurate bookkeeper.

Quadruplex (Transverse Track) Video Tape Recorders

It is commonly believed that we have lots of trouble achieving compatibility in those pesky helical-scan recorders, but quadruplex machines all use the same standards. Not so. There are two major variations:

1. High- or low-band modulation standards.
2. Narrow or wide gap widths in the recording heads and corresponding tape speeds.

These facts are quoted here only to make the point that these four-headed Standards of the Industry have some variations among themselves, explaining why prices for quadruplex machines may range from $25,000 to $110,000.

The following paragraphs are a concise summary of the performance levels, features, applications, and costs of the quadruplex recorders available through 1968.

The most versatile, highest quality tape recorder yet produced is the high-band quadruplex machine. These high-band machines were developed specifically for the recording and reproducing of the best possible color television images. As such, these machines are also capable of providing the highest quality black-and-white pictures, with a horizontal resolution of 400 lines[1] and an output video signal-to-noise ratio of 46db.

These machines are used generally in the major production centers and larger TV stations. They are almost always equipped with such features as electronic editing facilities, circuits for the automatic correction of timing errors, compensators for "drop-out" flaws in the tape, full electro-mechanical servos to optimize all characteristics of the reproduced image, and most complete monitoring facilities. The total cost of a machine so equipped is approximately $110,000.00.

Quadruplex machines operating on high-band standards can be purchased for as little as $50,000.00 by eliminating sophisticated optional equipment.

The machine that is still in most common use in TV stations -- both commercial and educational -- is the low-band quadruplex recorder, which has been on the market much longer than its fancy high-band cousin. These low-band machines can be equipped with all the optional extras and are capable of comparable resolution and video signal-to-noise ratio, but they don't do as well in providing high-quality color performance. The price range is from $35,000 to $50,000 depending on options.

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[1] There are several techniques for determining lines of resolution. Some manufacturers claim 400 or more lines for machines of lesser quality, but they do so on the basis of rather optimistic procedures.

A third class of quadruplex machines has been developed for closed-circuit use so that the vast store of resource materials available on two-inch transverse-scan tape can be utilized. These machines have been stripped of all the non-essentials in order to achieve a lower cost. Performance can be very good if the operator is experienced and understands videotape control intimately. These machines can be purchased for a little as $25,000.

Any of these machines can be equipped for tape speeds of either 15 inches per second or 7.5 ips. There are, of course, quality tradeoffs to be made, and we should examine them briefly.

It was pointed out earlier that the picture-to-snow (signal-to-noise) ratio is closely related to the width of the magnetic video track. This is why audio recordings of the very highest quality are frequently made on the full width of 35 mm magnetic film rather than on the familiar quarter-inch tape.

When we cut the tape speed from 15 inches per second to 7.5, we obviously have to figure out how to get the same number of transverse video tracks on half the length of tape. We do it by cutting the width of each track in half, from 10 mils[1] to 5. We just noted that this will necessarily affect the video signal-to-noise ratio.

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[1] A mil is a thousandth of an inch.

Also, while we have not cut the video writing speed (we still lay down the same number of tracks), the audio writing speed is cut in half, since the audio track is laid along the length of the tape, just as in conventional audio recording.

The major advantage of the lower tape speed is that we cut in half the amount of tape we have to buy, and video tape is expensive. For most purposes, the reduction in technical quality is not serious.

There are, however, other technical disadvantages, including a considerable reduction in the life of recording heads, which cost serious money to refurbish.[2]

With all these variations, the quadruplex machines are the standard of the industry, and their technical superiority over the helical-scan machines is undisputed.

Helical Scan, or Slant Track Video Recorders

A previous chapter noted the vastly confusing situation facing an administrator who had to choose among television cameras. That morass is exceeded only by the more recent confusion created by the introduciton of a whole new series of low-cost devices known as helical scan or slant-track video tape recorders.

This section will not dispel all the fog, nor will it make precise decisions possible. Indeed, one of the difficulties of of the print medium is that the situation will have changed -- probably for the worse -- by the time these words complete the journey from our typewriters to your desk. Nevertheless, there is a certain validity to the old principle of lighting a candle instead of cursing the darkness. The fact is that within the electronic jungle of slant-track recorders some basic principles continue to exist, and while we can't provide a paved highway to the right decisions, we can hack out some sort of thorny trail

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[2] $650 - $700 in 1968.

The dimensions of the thicket are noted below. As of 1968, all helical-scan recorders used some combination of the following design parameters:

1. Tape Width
    - a. Two inch
    - b. One inch
    - c. One-half inch
    - d. Three-eights inch
2. Tape Speed
    - a. 3.7 inches per second
    - b. 4.5
    - c. 6.9
    - d. 7.5
    - e. 9.0
    - f. 9.6
    - g. 10.0
    - h. 12.0
3. Writing speed
    - a. 130 inches per second
    - b. 550

3. Writing speed (cont'd)

   c. 590 inches per second
   d. 631.5
   e. 650
   f. 723
   g. 833
   h. 930
   i. 1000
   j. 1036

4. Number of heads

   a. One
   b. Two

5. Video track width

   a. 5.9 mils
   b. 6.0
   c. 6.2
   d. 7.0
   e. 7.1
   f. 7.5
   g. 8.0
   h. 10.0
   i. 15.0

Even if we ignore the last parameter (track width), elementary laws of mathematics reveal that a total of 640 different combinations of standards are possible. At last count, the industry was still well below that theoretical number. To the casual observer, however, it appears that the manufacturers are making every effort to close the gap. Should they succeed, there will be 640 ways to record video on slant-track machines, all incompatible with the other 639.

It is to be hoped, of course, that further proliferation of recording standards and tape formats will soon cease and that some of the manufacturers will agree to produce slant-track machines operating on common standards.

At this point, it might be well to discuss briefly three matters relating to slant-track video tape recorders: standards, compatibility, and broadcast quality.

Standards

Standardization is an absolutely essential requirement for quadruplex VTR machines ranging in cost from $30,000 to $110,000. Such machines are generally used not only to achieve maximum quality, but also to play back syndicated network tapes in both commercial and educational television stations. These tapes come from many sources, but the same machine must play them all.

As a matter of fact, this standardization between machines of different manufacture was virtually dictated by the broadcasters as a condition for purchasing. This is an important point to the educator, as it demonstrates once again the significant forces which are - in the final analysis - responsible for equipment standardization. Equipment standardization in any field - and television is no exception - is determined largely by what the purchaser demands as a condition for purchasing.

Expressed in a different way, equipment standardization is frequently determined largely by which manufacturer has sold the largest number of machines!

Unfortunately, helical-scan recorders are available in so many different standards and tape formats that the educator finds it very difficult - even with competent technical assistance - to make a good decision. This is a particularly critical dilemma in that the educator is acutely aware that merely to purchase a popular machine contributes to the acceptance of that standard - good or bad - while the purchase of a less popular brand operating on another standard serves to confuse the situation still further.

Compatability of Machines

If there is a single term which keeps popping up persistently in any discussion of helical-scan video tape recorders, it is "compatibility." Unfortunately, this term does not have the same meaning for everyone. For example, a given machine may be compatible with another machine of the same make and model, compatible with the same make but different model, or compatible with other machines of different makes and models.

As elementary as this requirement is, during the period when slant-track machines were being introduced, in order to obtain satisfactory results, it was necessary to play a tape on the same machine on which it was recorded.

As the electrical and mechanical tolerances of the machines were tightened, it became possible to play a tape back on any machine of the same make and model as the recording machine. As a matter of fact, even quadruplex machines passed through the same phases of "compatibility" immediately after introduction to the broadcast industry in 1956.

The next order of compatibility involves the ability to reproduce a video tape made on a "standard" slant-track recorder on any other "standard" slant-track machine of other manufacturers

At this writing, no two manufacturers of slant-track machines make use of the same recording standards and tape format. Some manufacturers have several models that are not compatible with each other.

However, there is a glimmer of hope. At least one manufacturer has marketed a series of five slant-track machines which make use of the same standards and tape width so that a recording made on any one of the series may be reproduced on any other model in the series. These machines range in price from the lowest cost $995 model to the "top of the line" model which is suitable for monochrome broadcast use selling for $12,500.

The Semantics of Broadcast Quality

The statement in the last sentence "suitable for monochrome broadcast use" implies that the video signal output meets all applicable EIA and FCC broadcast standards. The key word here is "applicable." We should not generalize too much and assume that a slant-track tape recorder meeting "broadcast standards" (frequently referred to loosely as "broadcast quality") exhibits performance as good as its more sophisticated quadruplex brothers. This term "broadcast quality" means only that the picture synchronizing signal delivered by the machine exhibits the required characteristics to insure a stable picture when received on a standard TV receiver.

We stated in an earlier chapter that the term "broadcast quality" provides virtually no assurance that the recorded video signals will be reproduced with the resolution or picture-to-snow ratio that are usual with quadruplex machines. Briefly, when applied to slant-track tape recorders, the phrase "broadcast quality" or "meeting FCC standards" usually refers to the synchronizing pulses and not the picture portion of the composite video signal .

The Purchase Compromise

Of course, it should also be recognized that slant-track machines are relatively new. At the time this is written they are undergoing a critical development stage which should result in marked advances. Tempting as standardization seems, then, it may not be - at this time - a desirable step, in that it could arrest the rapid technical developments now taking place in the industry.

Since the situation is so fluid, one of the major objectives of this section is to provide some basic information which may be applied to recorders in general. A detailed tabulation of the features and costs of currently available types would probably have a very short useful life.

The task, then, consists of:

1. Identifying the significant characteristics of the currently available recorders and establishing a relationship between these characteristics and the selling price.
2. Providing some specific suggestions and guide lines for making a choice between currently available slant-track VTR machines as well as new machines which are virtually certain to be marketed after this is printed.

Of the many characteristics of slant-track videotape recorders, the following are considered to be the most important from the educator's viewpoint:

A. Horizontal resolution, expressed in TV lines
B. Video signal-to-noise (picture to-snow) ratio
C. Synchronization stability
D. Initial cost and operating cost.

Horizontal resolution is a measure of the detail present in the reproduced image. Resolution is established by design parameters which have been discussed in previous chapters.

The video signal-to-noise ratio is a measure of the "picture-to-snow" ratio of the reproduced image. This important characteristic is established by such technical parameters as the width of the video magnetic track on the tape.

The characteristics of the synchronizing pulses accompanying the reproduced video signal are of particular importance when used with a broadcast operation. Unfortunately, this is one of the most difficult parameters to pin down since it is determined partly by the electronic design and partly by the mechanical precision of the machine itself. Specifications for this characteristic are generally not quoted by the manufacturer since very few slant-track machines are recommended for broadcast use. Further, the machines that are recommended for broadcast use are equipped with a synchronizing pulse processor, usually referred to as a "processing amplifier", to bring the shape of the pulses into compliance with FCC requirements. It should be noted that at the time of this writing, there is no slant-track VTR machine suitable for broadcast use unless it is equipped with either an internal or external processing amplifier.

Slant-Track Recorders and the Value/Cost Ratio

In an earlier discussion of the costs of instructional television equipment, we made the point that it is not the price alone that is important, but rather the value received for the money spent. With this thought in mind, the important measurable characteristics which are of interest to the educator, i.e., horizontal resolution and video signal-to-noise ratio, have been plotted against cost in an effort to establish a relationship between value received and cost.

Figure 35 shows the horizontal resolution in TV lines as a function of cost for 14 slant-track machines available in the

Spring of 1968. The straight solid lines represent the best average fit to the measured quantities provided by the manufacturers. Evidence of a marked trend or relationship is clearly evident even though we may assume considerable variation in the measurement methods of different manufacturers. An examination of Figure 35 suggests that the resolution is roughly proportional to cost only for the lower cost machine, those in the $995 to the $4,135 range. The correlation between resolution and cost is less apparent in machines of the $8,000 to $12,000 range, although this may be due to the availability of fewer examples in this cost bracket.

If any conclusion can be drawn from the relationship shown in Figure 35, it would seem to be that resolution is roughly proportional to cost in the price range from $995 to $4,135 and roughly independent of cost in the $8,000 to $12,000 range. Is the $12,000 machine no better than the $8,000 machine? It happens that the points on the chart corresponding to the $8,000 and the $12,000 machines are for recorders of the same brand and general type except that the $12,000 machine is equipped for color operation! It could be argued that the point corresponding to the color machine should have been left off the chart because it is out of place with the monochrome machines. However, including this machine on the chart demonstrates that very often it is the extra features available with a machine rather than improved performance, which increase the cost.

Figure 36 shows the video signal-to-noise ratio as a function of cost for the same machines. The results appear at first glance to indicate that the video signal-to-noise ratio is substantially independent of cost. Is it really possible to get as good a picture-to-snow ratio with a $995.00 machine as with one selling for almost $12,000.00? As we observed earlier, Mother Nature is a very good bookkeeper and we are not likely to get something for nothing.

Well, then, where did we pay the piper? Engineers know that the measured signal-to-noise ratio of a picture may be increased considerably by reducing the video bandwidth, but as we noted earlier, if we cut video bandwidth we impair the resolution. Superimposing our resolution - cost data of Figure 35 onto the signal-to-noise findings in Figure 36 reveals that this is indeed the case here. Although the measured video signal-to-noise ratio has been maintained with the lower cost machines, the resolution - the picture detail in the reproduced image - has been reduced. Further, we can note that neither resolution nor signal-to-noise ratio appear to vary significantly for recorders in the $8,000 to $12,000 price range. In this instance, at least, the additional $4,000.00 bought color, and not resolution or video signal-to-noise ratio.

The foregoing graphical treatment is not intended to be either definitive or complete. At best it offers some promise of a technique for evaluating performance received against money spent. It also indicates a method of separating technical performance characteristics of slant-track recorders from the optional features offered. Our attempt has been to develop a cost-benefit evaluation technique that would be applicable to machines developed in the future as well as to those available at the time this manuscript was prepared.

Some Additional Notes - - -

Before suggesting a specific set of general guidelines for purchasing a slant-track video tape recorder, a few additional comments may be helpful.

1. Although the market appears to be glutted with a vast array of slant-track machines with different brand names, it should be recognized that in some cases it is only the name plate and not the machine that is different. This is because some of the manufacturers of a broad line of electronic equipment offer, under their own brand name, machines that are manufactured by others. Thus, just because a recorder carries a different brand name, it should not be concluded that it is different from all other machines. Obviously, such machines are fully compatible with machines offered by the prime manufacturer under his own name. Therefore, when the prime manufacturer of a machine is identified, one can happily conclude that perhaps we already have some degree of compatibility between machines.

2. The authors believe that the "slow-motion" and "stop frame" features offered by some slant-track machines are somewhat oversold. Such features may be valuable for the analysis of certain sporting events such as football and have been used successfully for precisely that purpose. Although we do

not suggest that good educational uses for these features cannot be found, it is important that the educational innovator recognize that with the recording format presently employed with slant-track machines, the vertical resolution of the displayed "slow motion" or "stop frame" picture is exactly one-half the resolution obtained in the normal mode of operation of the machine. Furthermore, merely stopping the tape seldom produces a satisfactory picture without a "noise band" or "tearing" tendency in the upper part of the picture unless the position of the tape is adjusted manually to obtain a satisfactory "still frame" picture.

3. Some comments on the two-head vs. single head slant-track machines may be helpful. One of the redeeming features of the slant-track machines is the elimination of the electronic and mechanical complexities necessary with the four recording/playback heads of quadruplex machines. Thus it would seem that if these problems can be eliminated in "low budget" machines, it is reasonable to go to the irreducible minimum of one head.

One of the major advantages of the single head configuration is the lower replacement cost of heads and the fact that the head of some machines can be replaced in the field by anybody in a few seconds. The reason for this ease of replacement lies in the fact that the two-head machines require that the heads be precisely aligned with one another so that they record exactly parallel tracks on the tape. Obviously, this exacting adjustment is unnecessary on a single head machine.

4. Some slant-track machines are offered with two output channels. In addition to the usual direct video output, an R.F. channel allows the user to display the recorded program on an unused channel of an ordinary TV set. This is a desirable feature, but there are at least two limitations which must be noted. First, the R.F. output of some machines carries the picture information only, without the associated audio portion of the program. This means that a separate audio cable and speaker must be provided for playback of the sound. Furthermore, the nature of the R. F. output signal is usually such that it may cause interference in a multi-channel television system.

5. When evaluating slant-track machines, one of the most difficult problems is to assess the quality of construction and mechanical ruggedness. We might devise some simple tests, but it is clearly impractical for the prospective purchaser to obtain samples of several machines and drop them all from the same height to determine which machine disintegrates into the fewest pieces. At least one more reasonable alternative is to note the impractical for the prospective purchaser to obtain samples of several machines and drop them all from the same height to determine which machine disintegrates into the fewest pieces. At least one more reasonable alternative is to note the thickness of the tape deck which supports the head drum and the take-up and feed-reel spindles. Machines produced by the more quality-conscious manufacturers will generally use a heavier casting or a thick aluminum plate. The tape deck construction may well be an indicator of the quality of other less obvious but equally

important components inside the machine.

Purchasing Guidelines for Slant-Track Recorders

Now that you have decided to purchase one or more slant-track VTR machines, what procedures, if any, can be offered to help you make the best decision?

The authors offer the following guidelines:

1. Make a list of the features you want your machine to have, such as color capability, suitability for broadcast use, remote control capability (required for use in remote access retrieval systems), slow motion and stop frame features, electronic editing, etc. This step alone will eliminate a number of contenders.
2. Tabulate and plot vs. cost, the resolution and video signal-to-noise ratio characteristics of all slant-track machines available at the time of the proposed purchase. This is a point at which professional engineering assistance will be valuable.
3. In addition to the conclusions developed from Step 2 above, try to weigh the following considerations:
    a. The tape format used on available syndicated educational resource material which you may want to use.
    b. The per/hour cost of videotape required for the machine.

    c. Terms and conditions of the head guarantee, and the cost of replacement heads.
    d. Is the head assembly readily replaceable in the field or must the head drum or the entire machine be sent to a service station for head replacement?
    e. The availability of replacement parts without long delay, and the availability of service information.
    f. Does the manufacturer operate a maintenance training school which your service technician may attend?

4. Following the tentative selection of a machine, obtain a list of users from the vendor for the purpose of obtaining first-hand information of the performance and reliability of the selected machine in the field.

If the machine you have selected has the features you want at a price you want to pay and if it passes the test in Step 4 above, you stand a reasonably good chance of getting your money's worth.

The Television Tape Library

The television tape library is a major by-product of ITV and the television recorder. As one would expect, these libraries range all the way from the well-known centers (The National Great Plains Instructional Television Library and The National

Center for School and College Television) down to a few tapes in a box at the local school.

There is an easy tendency to equate television tape libraries with film libraries. The two are not much alike, however, and their differences can be traced to the transitory nature of video tape and television. Two fundamental differences between television and film are that television production generally consumes far less time, and tape stock can be re-used. Thus, an ITV production is hardly ever considered finished, cast in bronze for the ages. Television teachers and producers commonly retain professional rights over the product, so that it can be withdrawn or re-produced when it is out of date or when improvements become feasible.

On the local level, this characteristic is reinforced by the fact that tape stock represents a higher initial investment than film stock, and so there is a constant economic pressure to weed out little-used material and re-use the tape for better things.

By and large, films are acquired: while they can be used only in certain ways, the prints are for practical purposes the property of the buyer. Not so with instructional television tapes. Reflecting the transitory nature of television, the professional interests involved, and the economics of tape stock, ITV program tapes are generally leased for specific uses during short periods.

All of these factors raise again the problems of compatibility among tape recorders. Suppose your county (region, state) educators consider it desirable to set up a mechanism for the exchange of locally-produced ITV tapes. In how many electronic versions must each program be available? Nationally, the problem is merely a headache. Between two colleges or two school districts, electronic incompatibility may scuttle an otherwise good idea.

This discussion has touched on several ways in which tapes may be added to a local ITV library. It may be well to enumerate the sources and comment briefly on some mechanics. Tapes are acquired locally by:

... Local production.
... Distribution by national or regional centers.
... Making copies of others' production. (The copying process is called dubbing.)
... Taping programs as they are received off the air.

Some Notes on Off-Air Recording

The recording and reproduction process introduces two successive steps, each of which results in a separate degradation of picture and sound. And when we're recording off the air, the air, the signal as received may be none too good anyway.

If recording off the air is a requirement, however, step one is to assure a ghost-free signal of adequate strength available at the receiver.

Second, a professional-type, rather than standard, off-air receiver should be used. Such a receiver should provide audio and video signal outputs at the proper levels and at impedances that are compatible with the needs of the recorder.

Never -- and there are no known exceptions -- never try to make an off-air recording simply by pointing a camera at the TV screen and a microphone at the speaker. The results are a technical disaster.

Last (and we find ourselves picking on that low-cost helical scan recorder again), it's important to use a video tape recorder of the best possible quality to minimize the accumulated degradations in the final product as it appears on the classroom receiver.

A Caution About Copyright

In this discussion of ITV tapes and their various sources, one final caution should be expressed. The United States is in a major transitional phase in the evolution of its copyright law. Particularly with the advent of new communications technology, educators and copyright holders are carefully testing their respective positions. It is only prudent to stay abreast of the advice of professional associations, and to turn to local legal counsel in case of doubt. We may anticipate some really exotic test cases during the next few years; it's best to become involved in that sort of thing on purpose, and not by accident or neglect.

CHAPTER VIII

AND WHAT ABOUT COLOR?

Virtually no consideration of television facilities for educational use can be considered complete without some discussion of color equipment. The degree of interest in the capability to originate or distribute educational programs in color will depend largely on the type of operation. That is, a small closed-circuit operation struggling to appropriate funds for something a little better than equipment intended for an industrial surveillance TV system will wisely defer color consideration to a later stage of development. On the other hand, the large educational or public broadcaster is almost forced into color operations if only to avoid the image of second-class citizenship beside his commercial TV brothers.

In any event, at one time or another, the use of color must be considered by the educational facilities planner. Thus a few remarks on the subject may be helpful.

All color equipment may be classified into two categories. These may be labeled "color capable" and "color compatible". Standard color signals are compatible with standard black and white signals. Simply stated, this means that color signals will produce a satisfactory black and white picture on existing black and white sets. Thus it would be expected -- and this was certainly the objective of the planners who established the operating standards[1] - that compatible color signals could be handled by any good black and white transmission system. The technical fact of life, however, soon revealed that the satisfactory transmission of color signals imposed some special requirements. Consequently, it soon became obvious that many elements or building blocks of a complete black and white transmission system would have to be improved or upgraded if they were to be used eventually for the transmission of color signals. Such elements or building blocks of a black and white system may thus be referred to as "color compatible" to distinguish them from "color capable" equipment, which is directly involved in the origination or display, rather than handling or transmission of compatible color signals.

Examples of "color compatible" equipment are:

a. High-qulaity coaxial cables;
b. Video distribution amplifiers;
c. Video switchers.

Examples of "color capable" equipment are:

a. Live color cameras;
b. The pickup cameras in TV color film projection systems;
3. Color television sets or monitors.

The major purpose of the foregoing discussion is to emphasize the idea that as much black and white television equipment as possible should be color compatible, so that when you "go color" relatively little equipment will become obsolete.

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[1] The operating standards for modern color television systems were established in the early fifties by a joint industry technical committee known as the National Television Standards Committee. (NTSC)

THE PHASING-IN OF COLOR

Some major ITV installations have started with color in their initial designs. Most budgets still preclude that decision, however, and planners typically are interested in a reasonable "phasing-in" process. Good color equipment is inexpensive. "Color compatible" equipment costs little more than equipment capable of handling black and white signals only, but the costs of "color capable" equipment such as live cameras, film chains, video tape recorders and monitors/receivers run approximately three times more than black and white. To make economic matters worse, the factor of three must be applied to major items of equipment costing thousands, rather than hundreds of dollars.

Assuming that you are planning to start with a good black and white system and gradually phase-in color equipment as needed, the following specific steps may be followed:

1. All passive transmission equipment (i.e. cables) and active signal handling/processing equipment (i.e. switchers) purchased should be color compatible.
2. If a VHF or UHF broadcasting station is involved, the transmitter should be "color-proofed". This will usually involve some relatively minor terminal equipment at the transmitter plus an engineering showing to the FCC that color signals can be transmitted without excessive distortion. If a 2500 mHz system is involved, some minor terminal equipment will also be required to meet the FCC requirements. Thus with your transmitters "color-proofed", you are now in a position to accept network feeds or rebroad-

cast "off-air" color programs with the use of a good color receiver.

3. The next logical step is to provide the simplest color origination facility. This step may involve adding the necessary color modules to an existing video tape reproducer or adding a color film chain. The choice will depend largely on the type of black and white video tape recorder in use and the availability of color tapes for playback in the tape format (tape size and recording standards) employed in your shop.

   The addition of a color film chain may be considered an excellent starting point for the following reasons:

   (a) Color film chains are usually less expensive than live color cameras.

   (b) A wide range of color resource materials are available in 16 mm color motion picture films and 2 x 2 slides.

   (c) You can "produce" your own color materials with an ordianry 16 mm movie camera and 35 mm still camera with a playback delay no greater the film-processing time.

4. Colorize or purchase a color video tape recorder/reproducer - if this was not done in Step 3.

5. As a final step, acquire studio color film cameras along with the appropriate lighting facilities to permit the production of live color programs for immediate use or tape recorded for later use.

The steps outlined above will provide a relatively painless entry into color television without obsoleting your black and white equipment and will reduce the probability of loading your facility at one time with a lot of expensive color equipment which could be easily obsoleted by the rapid changes and improvements taking place during, and immediately after, the preparation of this guide.

CHAPTER IX

THE PEOPLE WHO MAKE THE SYSTEM WORK: YOUR ITV STAFF

The Tasks -

Whether the ITV staff consists of one man or a hundred, the jobs to be performed can be categorized quickly under the headings of administration, production, utilization, and technical. Somebody has to set goals, allocate resources, and mind the store (administration); work with teachers to plan the development and application of materials (utilization): prepare materials for use (production); and operate and maintain the hardware (technical).

These same general categories describe the tasks of the audio-visual staff of decades past, but television brought some important differences. Some of these differences are as follows:

1. Television staffs tend to be much more concerned with the production function. This is not merely a personal preference, but has to do with the transitory nature of television referred to in a previous section. Television programs, produced on a re-useable tape, are usually intended to have a relatively short useful life. Furthermore, even within that useful life individual programs or segments may be re-shot several times. A television series commonly undergoes a continuous updating and evolution throughout its lifespan.

2. A well-designed television series is usually much more integral to the curriculum than is a given film, set of slides, etc. A teacher selects a film as back-up to a specific

point in his work, but he conducts a kind of continuous interaction with a good television series. This fact has serious implications for the design of the television operation and ultimately for the educational strategy of the whole enterprise.

3. Although electronic equipment is constantly becoming more reliable and stable, it requires specialized maintenance. In an installation of even modest size, it is a good investment to have a man constantly available for preventive maintenance and trouble-shooting. Perhaps it should be noted that while film projectors, for example, function excellently, reasonably well, or not at all, a television system hardly ever fails to turn out some kind of a picture. This fact is a fault, not a virtue: a bad picture can make for a bad learning experience and hence an unsatisfactory teaching experience. Furthermore, a gradual degradation of quality is insidious. It occurs so gradually that it may go unnoticed and unrepaired. This equipment can't be kept in shape simply by changing a lamp, blowing out the dust, or oiling the motor.

Qualifications -

In considering the qualifications of ITV staff members, it's useful to consider separately those functions related to content (production, utilization, etc.) and those related to equipment.

Let's set aside for a moment the necessary qualifications of technicians and concentrate on the "content" staff.

Depending on staff size, the qualifications for specific jobs will of course vary. But the staff personnel required for administration, production, and utilization have some basic qualifications in common, and it is dangerous to ignore any of them. They are:

1. The ability to function effectively and easily in the educational community." These people must work well with other professionals actively involved in curriculum matters. By the very nature of things, these new staff members are apostles of change; personal and professional relationships are critical.

2. A sound knowledge of the medium, its capabilities and its techniques. This is a common deficiency. Particularly in small to middle-sized installations, ITV personnel all too often are those whose qualifications were as follows:

... They were available, probably already on the payroll.

... They were willing to take a whack at it.

The authors wish to express their appreciation for the fact that school districts don't use these criteria when hiring bus drivers.

In fairness, it must be admitted that the properly qualified person is all too rare, particularly at the prices that many administrators can afford. Still, a great many ITV facilities are serving their areas badly, simply because otherwise admirable people haven't the necessary training and experience in the medium. A large number of colleges and universities offer everything from short institutes to graduate study in this field. If it is necessary to begin ITV operations without a fully experienced staff, early training is urgently recommended.

3. A reasonably broad grasp of trends in educational technology. The person whose horizons are bounded by the television studio can do a long-range disservice. Educational practice is moving too rapidly to have any major staff member locked to one approach . The right ITV staff can be immensely helpful by keeping abreast of technological developments in related fields. If they are skillful and adroit enough, they can become an interesting and valuable avant-garde element in the curriculum group.

The Technical Staff

A television operation places in close working relationship two groups of professionals, the production staff and the technical staff. While we must guard against stereotypes, it is generally true that these two groups have different background different training, different professional interests, and (quite often, anyway) different temperaments.

In the conventional perception of the field, the production people are thought of as rather intuitive in approach, imaginative, creative, perhaps inclined to be extroverted. The technical people, on the other hand, are seen as deductive, methodical, and relatively introverted. The inter-group relationships are, in a word, not uniformly harmonious.

It's important, then, to select with particular care those key people in each group who will be working together regularly across that vague line that divides production and engineering. And it's equally important to invest the administrative time and skill to imbue all hands with the knowledge that each man is vital to the same goal: the instruction of students.

The real pivot position in this effort is probably that of your top engineer. He may be called the Director of Engineering, or the Chief Engineer, or, in a small installation, THE engineer. Our concrete advice: look for diverse attributes in addition to engineering competence when you hire your top engineer.[1] Of course he needs a sound mastery of the hardware, and he needs to be a good leader of other technicians. Hopefully, he understands the problems of production, and some general administrative ability is fine.

But look for other clues. If you find a man who meets sound technical criteria and also proves to be a serious amateur photographer -- or better still, an actor in the local theater group -- sign him up before he gets away. Chances are that he will contribute to amalgamating the entire staff into a harmoniously functioning single-purpose group.

Qualifications of Technicians -

In considering technical qualifications, it is well to put aside a couple of misconceptions. First and foremost, an FCC operator's license does not an engineer make. The first, second, or third class "ticket" is exactly what it says at the top: an operator's license which authorizes the holder to manipulate the controls and adjustments of transmitting equipment. As thousands of license-holding disc jockeys would agree, it is quite possible to study furiously, pass the test, and work as a licensed operator for years without having more than the faintest notion about the innards of the hardware. There are several positions for which licensed operators are required; these are people who operate transmitting equipment that is regulated by the FCC. There are lots of positions for which licensed operators are not required. Some of the largest commercial and educational stations in the country employ directors of engineering who do not hold current FCC licenses, since these men do not operate the equipment, but rather work with other people and with engineering ideas. In closed-circuit systems, a licensed man is likewise not required, since the FCC does not regulate such systems.

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[1] This principle is useful even in one-engineer shops. These places grow. Today he's a youngster with a soldering iron. But he's your senior man, and tomorrow you may find him behind a desk as Director of Engineering.

It is certainly not our purpose to demean the licenses or the people who hold them. But some administrators assume the license to be a sort of FCC endorsement of engineering skill, and there is not necessarily any correlation.

Within a technical staff, there is a range of necessary skills. We tend to think of the men who work behind the camera (or sometimes inside it) as "the engineers." It's likely that only one of them -- the technical anchor man, or Chief Engineer-- is properly called an engineer. The others are maintenance technicians or equipment operators.

From the standpoint of acquired skills, the operators can be trained most readily and generally command the lowest pay. Their duties consist of operating studio cameras, control room equipment, and such ancillary gear as tape recorders and film chains.

The maintenance technicians have a good working knowledge of practical electronics. This is a body of information that is not acquired quickly, and it is coupled with skill in using sophisticated electronic test equipment. These men conduct preventive maintenance routines, trouble-shoot breakdowns, make repairs, install equipment, and generally hold the place together. As you would expect, maintenance technicians generally draw somewhat higher salaries than equipment operators.

Perhaps the most helpful way to conclude this section is to emphasize two important points:

1. Plan -- even scheme -- at the outset for an effective maintenance facility complete with an adequate supply of spare parts. Try not to scrimp on test equipment. It will save you time and money in moments of stress.

2. Realistic salaries for maintenance technicians may be higher than you expect. The demand is great and the supply is short, and that situation is likely to prevail for some time. You may have to pay a little more than the local market price in order to attract a competent person. But if the equipment doesn't work, it matters not that everything else is perfect.

The Great Talent Search

Listed in a previous paragraph are three basic qualifications for non-technical ITV staff members. They were, briefly,

(1) the ability to work effectively in the educational community;

(2) sound knowledge of the medium, and

(3) breadth of understanding in educational technology.

Administrators who have assembled an ITV staff will probably agree that:

A. The criteria are valid to the point of being self-evident;

B. The combination is very difficult to find; and

C. That's one of the major problems in the entire development of instructional television.

(Continued on following page)

It is important to note that while the three criteria are listed in rank order, they are very nearly of equal importance. To focus the discussion, however, let's consider the first two: --- the ability to work effectively in the educational community, and sound knowledge of the capabilities and techniques of the medium. If a good balance is not struck between these two, the system will be used ineffectively and the goal of improved instruction cannot be met fully. These poor results will be caused by opposite factors, but the outcome will be similar. A little thought will show us why.

Consider the case of the man with good educational qualifications but a poor grounding in the capacities and techniques of television. He may get along very well with his colleagues, and he may be perceived as doing his job effectively. But everybody operates within his own frame of reference, and his television productions will often tend to look like encapsulated pieces of classroom teaching. The capacities of television as a medium different from the medium of the classroom are unlikely to be developed. To call the staff unimaginative is pointless and unfair; the imaginative use of anything -- television camera, classroom environment, or budget session -- requires knowledge and experience.

Interestingly enough, an ineffective use of the medium may also result from the employment of a person who is skilled in television production but lost in the field of education. True, the bad productions may look a little fancier, but they will be bad neverthless. The reason is that either of two things is likely to happen:

1. The television man, recognizing his instructional inadequacies, leans heavily on the teacher or curriculum developer. Unfamiliar with the principles of instruction, and reinforced only by recollections of his own school days, he can do no more than assemble on tape the ideas that "those educators" give him. Since the educators are oriented to the classroom and not to television, the programs once more come out looking like magnetic facsimiles of classrooms.

2. Or the television man does not recognize his instructional inadequacies. He mounts his charger and rides forth to re-make the old-fashioned educational system. The results of this approach are too painful to elaborate further.

In setting down these examples, we must avoid carrying stereotypes too far. ITV is still so new that few of its leaders set out with instructional television as a career goal. Rather, they began as classroom-oriented teachers or administrators, or as television practitioners, and they found that they could broaden their professional skills into new areas.

Some television practitioners have become excellent in curriculum development, and some classroom teachers have become fine television producers. But the key work is become.

IN SUMMARY: In staffing your ITV facility, the man you're looking for is not likely to be on your present staff in some other capacity, and he is not likely to be a commercial television practitioner who comes equipped only with the techniques of the medium. More and more professionals are qualifying themselves specifically for educational communications. If you can find one, sign him up. If you can't find one, insist on further training for the man you choose. But your ITV system is too expensive, and its potential is too great, to whittle away its chances through assignment of the wrong staff.

Student Production Help vs. Professional crews

Consider the Saturday football game or the evening newscast on your home television set. The pictures are in focus. They change with the progress of the program so that you see what's important at any given moment. The screen is neither darkly muddy nor over-bright. In other words, you can concentrate on what the program is about, and not on how it's done.

Clean, unobtrusive production is done by people who are skilled and practiced at their jobs, whether they are directors, cameramen, lighting technicians, or operators of control equipment. As indicated above, this technical smoothness is needed not merely so the program will sound and look "professional," but so that the program will do what it is supposed to do.

Technically awkward production interferes with communication. The viewer is asked to dig out the intended ideas even though he can't hear well, or even though the crucial picture is out of focus, or even though he is being told about one thing but shown another. Any number of elements can interfere.

And that is the essential argument for the use of professional production crews rather than students in the production of instructional television materials.

Students, however, are commonly used in ITV production, whether the installation is in an elementary school or in a university. The reasons for using them are usually:

1. They are available.
2. They cost little or nothing.
3. The television experience is good for them.

They are undeniably available, the price is right, and they usually enjoy the job. Whether the experience is good for them probably depends upon individual cases. If the production is a laboratory session tied to a college course in broadcasting, the experience is at least logical. If the production is conducted by sixth grade boys, the value to them is less clear.

But if the ITV production process is intended simultaneously to be a learning experience for the crew, there arise serious questions of means and ends. Consider, for example, the following analogy. If you are teaching sixth grade social studies, you may give Johnny Smith an A for his paper on Honduras. If you are also writing a textbook for sixth grade social studies, however, you are not likely to incorporate Johnny's paper in it. Excellent performance in one context does not constitute excellent performance in another. With regard to Johnny's paper, you must decide whether you are teaching social studies or writing a book. With regard to Johnny's performance as a cameraman, you must decide whether you are teaching him a skill or producing a program for the instruction of other students.

In instructional television production, we should avoid anything that cuts our chances of realizing the program's instructional objectives. If the program is of some benefit to the production crew, that is all to the good as long as the quality of the program is not impaired.

That principle need not rule out the use of student crews, but it implies certain guidelines. These might be stated as follows:

1. Students should have acquired technical skills before they are assigned to ITV crews. Actual production can be fine experience for students, but it is no place to build basic skills.

2. Within ITV crews, students should be assigned so that their skills are used to support the production, and not so that the production will help overcome their weaknesses.

3. As Aristotle used to say, the audience (and not crew training) is the end and aim of the production.

There are some additional factors to be considered when students are used in production crews. These are based on rather wide experience:

A. When students are used in production, the job generally takes longer than it does when professional crews are used. Even your best students are relatively slow to pick up instructions, and they need more detailed direction than professional crew members. They are more likely to make mistakes.

B. This longer production process may well affect the performance of the TV teacher. When the process drags, some of the intuitive sparkle and spontaneity are likely to sag.

C. The presence of students may affect the relationship between the TV teacher and the director.

D. Students' class schedules are a continuing complication in crew scheduling.

All of the above notwithstanding, a great many successful ITV productions have been done with student crews,[1] and it is a hard fact that many productions would not have been done at all were it not for the availability of student crews. Nevertheless, it is well to look at all sides of the problem before assigning to students tasks that ordinarily require professional attention. If you have been told that there is not really that much difference between student and professional performance, call your TV station manager and ask him what he pays his production crews and how difficult it is to recruit good ones.

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[1] Television production is being used also as a means of expression for students. The thrust of this chapter, of course, is the development of curriculum materials for students who are primarily classroom users, not creators of programs.

CHAPTER X

PLANNING THE ITV SYSTEM

How to plan the ITV system? There is, of course, no single way. The kinds of systems are many and diverse, and human organizations blessedly vary with the humans involved. There are, however, a few basic decision points and a few principles which, while they may seem obvious, also appear to be workable. This chapter will discuss some planning principles, the roles of those involved in planning, and some thoughts concerning quality and cost.

Here is a basic planning pattern:

1. Take a long and careful look at your _entire_ requirement for instructional and administrative communication.

2. With good professional help, relate the potentials of television to the tasks before you. While reserving the final decisions for yourself, take the professional counsel seriously unless you are already expert in television.

3. At this point, you may decide that television _isn't_ the answer, that the potentials of television in fact _don't_ match the requirements of your situation.

4. If you decide in favor of television, now is the time to make policy as specific as possible. In detail, and with the advice of someone who knows the medium thoroughly, set forth the objectives of the television system. Objectives

should be addressed to the following broad categories:

a. Students and professional groups that are to be served.

b. Nature of material to be transmitted.

c. Amount and kind of production to be undertaken, if any.

d. Nature of related systems, such as feedback systems to computer centers, dial-access components, etc.

5. Not later than right now, engage the best telecommunications design engineer that you can afford.

6. Making full use of consultant help, design the technical system, determine the staffing requirements, and plan specific administrative arrangements.

7. Budget for operations and capital outlay.

8. Build in budget factors for future development.

9. Decide whether you can afford the package developed thus far. (Although you have money invested in planning, you have not yet bought any hardware.)

10. If you cannot afford it, congratulate yourself on having found out before it was too late. Then decide on alternative courses: modify plans, phase the development, forget the whole thing, etc.

11. If you opt for modification, play the game fairly and go back to step 4, the determination of objectives. Afterall: if at this point you can reduce the size of the project and keep the same objectives, somebody has been cheating.

12. Having decided as well as you can that there is conformity between objectives and plans, proceed with construction. Ideally, your principal staff person will come into the picture about now, so that he can supervise construction and add his personal touches while the installation is still taking shape.

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Having established these guidelines, let's turn to specific parts of the problem and specific roles undertaken by key people.

SOME KEY ROLES IN PLANNING

The Role of the Educational Administrator

The administrator's traditional functions are to set policy, allocate resources, and supervise operations. And so it is in planning the instructional television system. It seems to us that the administrator's basic tasks here are to:

a. Decide whether to use televison.

b. Set the objectives of the system.

c. Allocate funds.

d. Set the ways in which the system will fit into the overall structure of the educational enterprise.

e. Supervise staffing in accordance with the previous decisions.

f. Determine whether the ITV project in fact meets the stated objectives. If it does not, establish corrective measures.

This bare statement, however, sets forth critical tasks without touching on some of the most important problems likely to be faced by the administrator.

Modern communication does not merely permit us to do more conveniently the same things we always did. It has been pointed out that the elevator did not merely make it unnecessary for us to climb stairs; it made possible the development of the skyscraper. Similarly, modern communication technology allows us to re-examine the structure of instruction and administration. Television is pervasive. It tends to be felt throughout the system. Many people are touched by it, and some of them are likely to feel threatened or by-passed. As in so many areas of successful innovation, the name of the game is Involvement. And this, you would probably agree, requires the most crucial and ingenious forms of leadership.

During many of the steps noted above, the administrator should have at his command appropriate consultant help. The decision to use television should come after a study of alternatives. The allocation of funds can be made most judiciously in steps, beginning with feasibility studies, so that the financial commitment at any stage is no greater than necessary. The objectives of the system, and the way it can fit into the overall educational structure, can be moulded and sharpened in conjunction with a person skilled in the development and implementation of such systems.

The Role of the Classroom Teacher

Of all the professionals in the educational enterprise, the practicing teacher is probably affected the most by television. Television tends not to be "just another classroom resource," but becomes a day-in, day-out part of the curriculum. Properly used, it greatly enhances the creative role of the teacher and helps make possible a more individualized relationship to the student. It is important, then, that teachers be actively involved in the planning process. Their likely roles are:

a. Participate in advance studies on the use of educational technology in your situation.

b. Learn about the uses of television in instruction and the techniques of classroom utilization.

c. Help determine the objectives of the television system, and set priorities among possible uses of the medium.

d. Participate in curriculum committees to determine the objectives and content of specific series.

e. When the system is operational, provide feedback on the usefulness of materials, ideas for improvements or further development, and recommendations for relating television to other aspects of instruction.

Most teachers have long since dismissed the shibboleth that television will somehow replace them. People working day by day in instructional television almost invariably find that good classroom teachers are their best friends, providing extremely valuable advice and very strong moral support.

The Role of the Television Administrator

In considering the role of the instructional television administrator -- the person who runs the ITV system -- one is tempted to make an over-general statement, like "Mind the store." To a certain extent, the temptation is useful, because the ITV administrator must be a generalist who knows instruction, who understands the capabilities of his medium, and who can apply these capabilities in specific situations. In a previous section it was remarked that he had to:

a. Have the ability to work well in the educational setting

b. Have a sound knowledge of his medium

c. Have a reasonably broad grasp of the applications of technology in education.

To be more specific, however, the ITV administrator must:

1. Supervise the construction of the system and its subsequent maintenance
2. Within the established policy objectives, set the working goals of the system
3. See that the system is operated in accordance with these goals and objectives.
4. Recommend changes in objectives, budgets, procedures, personnel, or equipment in accordance with what he considers to be the continuous improvement of the system
5. Maintain extremely close liaison with the other aspects of the curriculum effort
6. Maintain sound working relationships (concentrating on open lines of communication) with teachers and other professionals involved in the use of television;

7. Select and supervise personnel
8. Maintain careful cost records and work toward improvements in cost efficiency
9. Regularly evaluate the performance of the system in the light of stated objectives. Recommend or execute changes as necessary.

The Role of the Consulting Engineer-

Perhaps it is not surprising that a great many people simply don't know what they should expect of consulting engineers. The average educational administrator, after all, doesn't have occasion to call on one very often. For that reason, we have prepared an appendix that treats in some detail the kinds of services offered, some rules of thumb regarding costs, and similar material that might help establish a sound working relationship between administrator and engineer.

In the present context, let's consider briefly the kinds of services performed by consulting engineers and what a client should expect of his consulting engineer. In the following, we borrow liberally from the guide published by the Consulting Engineers section of the Florida Engineering Society. You will find this material consistent with policies of the National Society of Professional Engineers.

Services Performed - For present purposes, we may consider four general categories:

A. Preliminary Report Services, which broadly include feasibility studies and preliminary engineering studies that indicate the problems involved and the alternate solutions available, financial investigations, preliminary layouts and sketches, analyses for future development, general cost estimates, and the consulting engineer's recommendations.

B. Design Services, which are ordinarily divided into a Preliminary Design Phase and a Final Design Phase. Design services usually include preparation of detailed drawings and specifications, assistance in the preparation of documents such as the engineering sections of FCC applications, final cost estimates, and assistance in working with bidders and contractors.

C. Professional Services During Construction, which normally include periodic site visits, interpretations of contractors' drawings and documents, and a final inspection to determine that the specifications were met and the system operates as designed.

D. Additional Services, such as resident project services, accommodation of changes in the project, furnishing additional copies of reports, assistance in staffing the completed installation, serving as expert witness in proceedings related to the project, etc.

In providing these services, the consulting engineer can be expected to adhere rigorously to certain operating principles and ethical standards. We quote from the Florida Engineering Society:

> One can expect the Consulting Engineer:
>
> To inform himself fully in regard to the scope and services required for each project and to have the experience and

ability to qualify him for the services to be provided.

To provide the staff and facilities necessary to furnish the complete service through all phases of preliminary planning, design, and construction.

To retain and confer with specialists on unusual matters outside the scope of his regular services.

To have the experience and ability to analyze and design the most economical improvements consistent with budgetary limitations, expected life of improvement, and latest technical advancements.

To perform the services in an expeditious manner.

To furnish experienced construction observers who will keep the client advised on engineering matters pertaining to the construction project, and who will work toward the goal of obtaining the results prescribed by the plans and specifications.

To possess the ethics and qualities of a professional man to represent the client in accordance with the highest standards of professional conduct, always within the Code of Ethics as prescribed by the National Society of Professional Engineers . . .

The Role of the Educational Telecommunications Consultant

When the consulting engineer designs a system, he needs the most precise information about its intended use, likely growth, future implementation, etc. As the educational administrator contemplates his future system, he needs to know as much as possible about the instructional potential of various technical approaches, the administrative pitfalls encountered by others, some tested means of introducing the system and encouraging its use, the budgetary realities likely to be encountered later, etc.

The healthy project takes into account such variables as the impact of internal organization, the possibilities of cooperation and program exchange with neighbor systems, national trends in the use of educational technology, the blue-sky thinking that may turn out to be tomorrow's commonplace, etc.

The man who is called upon to assist both the administrator and the engineer in weighing these factors and shaping the final project is the educational telecommunications consultant. Generally speaking, his functions may be listed as follows:

1. Assist the educational administrator in determining which of his educational objectives may be furthered through the use of communications technology, and how.

2. Help sharpen the educational objectives of the future system, probably working with local committees as well as with administrators in the process.

3. As the project begins to take shape, work with the consulting engineer in examining the alternative technological solutions to the problems posed and recommending courses of action.

4. Develop budgets for operations and administration of the system as the engineer develops technical budgets.

5. Work with administrators as requested in staffing the system.

6. As an impartial outsider, work with local groups in introducing the system, acquainting staff members with its

potential, and helping them learn to use the system in a way that is helpful to them and furthers the educational objectives of the project.

7. Assist in evaluation of the system and its use. Work with the educational administrator, consulting engineer, and local system staff in making adjustments or corrections if necessary.

It's clear that a consultant in educational telecommunications is going to be different things to different people. In relatively small projects that have comparatively obvious educational objectives, an outside consultant may not be a worthwhile investment. If serious money is to be spent, and if the system will have a significant impact on the work of the educational enterprise, it is probably useful to involve a professional who has unusual knowledge of the technological alternatives as they bear on instructional problems; one who can work with local people but who has no local axes to grind.

Probably the most reliable source for information about educational communications consultants is through the major professional associations: The National Education Association, the National Association of Educational Broadcasters, and the Joint Council on Educational Telecommunications.[1] These and other sources are discussed in Appendix III.

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[1] The addresses of these associations are·

National Education Association, 1201 Sixteenth Street, N.W.,
Washington, D. C. 20036

(see next page for continuation of addresses)

The Role of the Building Architect

The role of the architect may or may not be particularly important to this discussion, depending on the size and nature of the project at hand. In general terms, the role of the architect is familiar enough that there is little point in reciting it once again, but some specific ideas may be of use.

1. Like the consulting engineer, the architect has a great need for information. Before he can do a sensible job for you, he needs to know in detail the requirements of the structure. Not clients' renditions of floor plans, which are probably the bane of his life, but the results of a commonsense, thorough study of the total project and of each individual function.

2. If the project is relatively conventional, the architect most often goes to work seriously after the consulting engineer has completed his basic study and the hardware portion of the planning is well advanced. The work of the engineer provides input for the architect. This is not to say that the architect comes in after the engineer has gone home. Their work overlaps.

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[1] (addresses cont'd from preceding page)

National Association of Educational Broadcasters
1346 Connecticut Avenue, N.W.,
Washington, D. C. 20036

Joint Council on Educational Telecommunications
1126 Sixteenth Street, N. W.
Washington, D. C. 20036.

JCET is a council of several leading professional associations in education.

3. In a major development or if unusual approaches are being attempted, the architect and the engineer should join forces from the beginning, and they should both meet the project as early as possible. Given an opportunity to interact early, the two can avoid waste motion in planning and wasted money in construction.

4. By the nature of his job, the architect is an experienced middleman. He is accustomed to sitting in a conference and winnowing out ideas to be related and put to work. This capability should not be overlooked as planning progresses.

The Quality Slope

From time to time one hears a line that sounds like this: "Why buy the expensive camera? The classroom receiver can't reproduce that good a picture."

This idea has a certain surface logic, but it is based on a misconception. The picture signal that arrives at the receiver is never as good as the signal that left the camera. All sorts of minor impairments and degradations take their toll. They can be minimized, but they exist. If you begin with a picture that is only as good as the receiver will display, the picture as finally displayed will be terrible.

This problem can be demonstrated by the simple graph in Figure 37. Study of the graph will also make the remedies obvious. It can be seen that the initial quality of the studio scene is extremely good. As it is converted into electrical signals and passed through the production hardware, however, small impairments creep in. Each flaw may be so tiny as to be imperceptible, but the cumulative effect is already at work.

Quality takes a sharp drop in the process of recording and playing back the program. Still other small degradations are introduced by the transmission machinery and the process of broadcasting or cable transmission. Antennas and distribution systems add their small errors. Videotape recording at the reception point may cause another sharp drop.

Finally, degradation introduced by receivers may be enough to drive the final picture -- the only one that matters -- into the "unusable" category.

Given the simple fact that a "quality slope" of some magnitude will exist, how can we assure that the classroom picture is good enough? A look at the diagram will point the way. We can:

1. Start higher on the quality scale. The same slope angle could then bring receivers into the useful range.
2. Reduce the sharp vertical drops caused by recording. This may be done by investing in better recorders or perhaps by eliminating one of them.
3. Raise the quality of production, transmission, and distribution systems in order to flatten out the angle of the quality slope.

4. Raise the quality of the classroom receivers, which cause a very sharp drop in final quality.
5. Devise some combination of the previous four possibilities.

COST TRENDS

Throughout this book, we have attempted to use actual cost figures only when prices seem likely to be more or less stable. Current costs quoted are for mid-1968.

In order to provide some basis for projecting future costs, however, we have plotted cost trends for selected items over the past 15 years, then we have allowed the resulting curve to extend a few years into the future. As you will see when you consult the graphs, equipment in general has advanced in price about three percent per year. Some items -- notably television receivers -- have come down in price markedly over the past several years.

CONCLUSION

It is all too easy to take an advocate's view of instructional television. Television and related technology are potentially so much more than "just another classroom tool." The dream of equal educational opportunity is brought closer. Truly individualized instruction is no longer a vague piety. Rapid growth may lose some of its chaotic character. We can change not merely the techniques of education, but its aspirations.

Given this potential on the one hand, and on the other the familiar traditions and the established patterns, it is small wonder that instructional television is perplexing as well as challenging.

Ideally, instructional television should be designed into a system of education when the system itself is created, and it should be used by teachers and administrators who are as proficient and comfortable with television as with books or telephones or electric lights. Since that will not be possible for at least a generation, we must plan all the more carefully and try as best we can to anticipate the future and plan for it.

We conclude our little book, then, by repeating our two major points:

1. Think first about educational objectives and second about technology.
2. Get expert advice before the planning process is far advanced.

And, as we began our first page with a thought from a wise man, we conclude our last with a quotation from another. In his Journal of April 10, 1854, Henry David Thoreau wrote:

> I bought me a spy-glass some weeks since. I buy but few things, and those not till long after I begin to want them, so that when I do get them I am prepared to make a perfect use of them and extract their whole sweet.

APPENDIX I

THE CONSULTING ENGINEER AND THE PLANNING PROCESS

Some of the most frequently asked questions relating to the selection of a consulting engineer are as follows:

1. Do we really need a consulting engineer?
2. How does one go about selecting a consulting engineer or engineering firm?
3. What can we expect from the engineer or firm?
4. What kind of information or guide lines should the engineer be provided with?
5. How much should such services cost? Can we really afford the services of a consulting engineer?

Let's consider these questions one at a time.

1. Do we really need a consulting engineer? To a large extent, the answer to this question hinges on at least two important factors:

    a. The size and scope of the project contemplated.
    b. The range of qualifications and experience in the existing technical staff.

Two extreme cases will illustrate the point. It would be absurd for a large television station, manned by a competent staff, to retain outside professional counsel when purchasing a relatively minor item of equipment. It would be equally absurd for an institution plunging into an ambitious television development to commit large amounts of money without the advice of an experienced consulting engineer.

A serious entry into the field of educational telecommunications starts the administrator on a long and rocky road. The consulting engineer has been over that road many times, and he can be of a great help in avoiding pitfalls and potholes.

Extremely important is the fact that the reputable consulting engineer is independent, with no allegiances except to his clients. He has no ties with any equipment manufacturer or supplier: he starts with your objectives, and not with somebody's line of hardware.

Should you retain a consulting engineer? While the answer is not always obvious, the question is always worth asking. If there is some doubt, the chances are that you should retain one. By and large, you will find yourself ahead both in terms of finance and the effectiveness of your system.

2. How does one go about selecting a consulting engineer? A good engineer's main stock in trade in his reputation. Reputations are based on successful and satisfactory service over a long period to a large number of clients. Consequently, at least one good approach is to conduct an inquiry of established institutions who have retained consulting engineers. Ask them for their recommendations. At least one large educational client is known to have selected his consulting engineer after requesting lists of recommended consultants from a number

of national educational agencies. He selected the one name that appeared on every list. Obviously, this approach doesn't give comparative information about the engineering firms, but it shows who has satisfied clients.

Additionally, virtually all states have engineering registration boards or engineering societies which publish a directory of registered professional firms. These societies may also publish guides to assist in the selection and compensation of consulting engineers. Much of the information in this section is taken from such a directory published by a section of the Florida Engineering Society, which in turn is affiliated with the National Society of Professional Engineers.

3. What can we expect from the engineer or firm? To that question the first and foremost answer is the obvious one: honest and objective engineering advice based on long experience and training.

To quote Florida's guide:

> What to Expect of a Consulting Engineer --
>
> One can expect the consulting engineer:
>
> To inform himself fully in regard to the scope and services required for each project and to have the experience and ability to qualify him for the services to be provided.
>
> To provide the staff and facilities necessary to furnish the complete service through all phases of preliminary planning, design and construction.

To retain and confer with specialists on unusual matters outside the scope of his regular services.

To have the experience and ability to analyze and design the most economical improvement consistent with budgetary limitations, expected life of improvement, and latest technical advancements.

To perform the services in an expeditious manner.

To furnish experienced construction observers who will keep the client advised on engineering matters pertaining to the construction project, and who will work toward the goal of obtaining the results prescribed by the plans and specifications.

To possess the ethics and qualities of a professional man and to represent the client in accordance with the highest standard of professional conduct, always within the Code of Ethics as prescribed by the National Society of Professional Engineers.

4. What kind of information or guidelines should the engineer be provided with? In order to crystallize his own requirements and provide a base for a contractual arrangement with the engineer, the client should write as complete a description as possible of the proposed project. Such a description should begin by stating clearly and completely the educational goals of the project. The remainder of the description should include budgetary limitations, the anticipated starting and completion dates for the project, and all other factors that may affect the agreement for proposed engineering services. If a formal contract is drawn up, it should explicitly include such matters as

the kind of raw information the client will provide, the engineer's proposed schedule, compensation arrangements, and such detail as the cost of additional copies of the project report, etc. 5. How much should such services cost? Can we really afford the services of a consulting engineer? A good consulting engineer, retained early in the planning stage of the project, is very likely to save more than he costs. Furthermore, the system he designs has a very high probability of success, both in terms of cost effectiveness and in terms of educational goals.

Perhaps the key to this happy arrangement is to call on a consultant very early in the game. A major university recently completed a new building which theoretically included full provision for instructional television. A consulting engineer was then called upon to work out the system. After a careful study he was forced to report that the university had two alternatives:

(1) Make expensive and time-consuming changes in the brand-new building, abandoning the carefully installed conduit system without ever using it, or

(2) Change the educational objectives of the building, the cost of which was two million dollars.

An early investment in the services of a consulting engineer clearly would have been a wise move.

All this notwithstanding, it is only reasonable to ask how much competent engineering services should cost. We turn to the profession's view of itself and borrow again from the Florida Engineering Society. First, some financial pitfalls to avoid:

It is in the best interest of the client to avoid the following:

1. Competitive Bidding...

   Minimum overall costs of the completed project including construction, operation, maintenance, engineering, legal and financing, should be the goal. As engineering judgment and analysis affect all costs, the best qualified engineers will produce the the most economical project. The profession is united in the belief that competitive bidding is in the interest neither of the client nor the engineer and is considered unethical.

2. So-called "Free Engineering"

   One should be alert for an arrangement whereby the engineering is "free". Adequate engineering is never free. In such an arrangement the charges for engineering services can only be hidden, and the total cost will most likely be greater than if the charges are clearly identified. Packaged arrangements combining both engineering services and construction invariably involve a conflict of interests detrimental to the client and the public.

3. Contingent Charges for Professional Services...

   To retain an engineer on the contingency that the engineer is compensated only if a project proves feasible or on the contingency that construction work will be performed in the future, is neither in the best interest of the client nor the profession. This practice is condemned by the Florida Engineering Society.

A consulting engineer is compensated for his services in various ways.

Different bases are used for compensating the Professional Engineer in Private Practice, depending upon preference or circumstances.

Recommended methods for compensating the engineer or the engineering firm are:

1. Lump sum;
2. Payroll costs times a multiplier;
3. Total cost plus a fixed charge;
4. Percentage of construction costs;
5. Per diem rates;
6. Retainer;
7. Combination of methods.

Lump Sum

When it is possible to define clearly the scope of the project and the engineering services to be performed, the lump sum charge may be agreed upon for total compensation. The scope of services should be described completely in the agreement to avoid possible minunderstandings. Any contract of this type should provide for payment for additional services on an agreed basis.

Payroll Costs Times a Multiplier

When the scope of work and professional services cannot be clearly defined, the charge may be based on payroll costs including salary plus all benefits such as vacations, sick leaves, insurance, record costs, and other fringe benefits, times a multiplier which usually ranges from 2.00 upward. In addition to compensation as computed by this method, reimbursement should be made for travel, subsistence, telephone, telegraph, cables, prints and printing costs and general out-of-pocket expenses required specifically for the project.

Total Cost Plus a Fixed Charge

This method of payment is a variation of the payroll costs time a multiplier method and applies under similar conditions. The engineer should charge all costs (payroll, overhead, travel, telephone, subsistence and similar out-of-pocket expenses) plus a fixed dollar amount for profit.

Percentage of Construction Costs

Percentage of construction costs is a method which has been used extensively in the past for establishing compensation for professional services. While there has been a definite trend away from this as a basic method in projects for which the scope can be established, it has been used for many years and may be desired by clients who have traditionally relied upon it.

The Cost Curve

The cost curve (see graph nearby) is a guide which sets forth a range of charges for design services and professional services during construction. For the purposes of establishing charges for the separate phases, the following allocation of the charge as computed from the cost curve is suggested:

A. Design Services

Preliminary design phase -- up to 40%, of the charge computed from the curve.

Final design phase -- up to 80% of the charge computed from the curve.

B. Professional Services During Construction

Up to 40% of the charge computed from the curve.

The cost of preliminary report services and additional are in addition to the cost reflected by the curve.

The percentage charge from the cost curve is applicable to each construction contract for which separate designs and contract documents are to be prepared.

The costs reflected by the solid line represent projects of average difficulty. Projects of less difficulty shade downward and projects of more than average difficulty shade upward. In all cases the curve reflects cost of new work only.

Alterations, renovations, and additions fall above the cost reflected by the curve. Compensation for these services are not covered by the curve and compensation should be by one of the other methods.

Per Diem Rates Plus Expenses

Per diem rates for personnel plus out-of-pocket expenses required for the project normally are used for short-time engagements, especially for personal services involving advice, reports, investigations and similar types of activities for which little or no design, detailed drafting or other services are required.

The per diem rate for principals of firms usually ranges upward from $150.00 per day plus out-of-pocket expenses for all time spent on the work in any twenty-four hour period. A lesser charge is made for engineering personnel other than principals. In this case the charge method should be payroll costs times a multiplier.

Time should be measured portal to portal and charged from the office or base involved. A minimum of one-half day should be charged on irregular work required out of the office or base, with telephone office consultations on an hourly basis.

Rates for consultation in connection with litigation and appearance before commissions and courts usually range upwards from $150.00 per day plus out-of-pocket expenses. However, if appearances in court require more than two days per week, the per diem rate should range upward from $175.00 per day.

Retainer

The employment of Professional Engineers on a retainer basis is a common practice which assures the client of always having available the services of a Professional Engineer. The amount of the retainer varies with the character and value of the Professional Engineer's service to the client. The terms of agreements for services on a retainer basis vary widely. Compensation may be based on a fixed sum paid monthly, or on some other mutually agreed basis.

Combination of Methods

Various combinations of methods for determining total compensation for professional engineering services may be desirable for some projects. Some projects may require rather extensive investigations and analyses before the scope of the project and services are known. For example, this situation may be covered by payroll cost times a multiplier plus out-of=pocket expenses until the scope is developed, then by lump sum for remainder of the service.

Consulting Engineer or Engineering Consultant? At first glance, it may seem that there is a distinction without a difference. But not so. The basic difference is a legal one: most states register professional engineers, and a person may not represent himself as an engineer unless he meets standards of training and experience and then successfully completes a rigorous examination.

This is not to say, of course, that any consulting engineer is by definition better than any engineering consultant. It is fair to suggest, however, that a client who is dealing with strangers has more technical and legal protection if the stranger is a registered professional engineer.

APPENDIX II

FEDERAL COMMUNICATIONS COMMISSION

WASHINGTON, D. C. 20554

INF BULLETIN NO. 16-B

April 1968

EDUCATIONAL TELEVISION

Television has become an integral part of quality education, cultural enrichment and information. It has brought into the classroom instructors, demonstrations and visual and aural materials that have greatly increased the value of students' learning experiences. It has brought into the home cultural events, public affairs presentations and a variety of other programs heretofore available only to those relatively few who had the means and the opportunities to seek them out in areas where they were available.

The first noncommercial educational television station went on the air in May, 1953. Fifteen years later more than 150 ETV stations reached a population area of about 160 million persons, and it was estimated that some fifteen million students in more than two thousand educational institutions, including elementary, secondary and higher education, were receiving all or part of their instruction through television. In addition, more than 145 applications had been filed with the Federal Communications Commission for over 400 channels in the Instructional Television Fixed Service (2500 megahertz band) since that service was established in 1963. Some 2000 closed-circuit television systems were serving public and private education, industry and various service agencies.

The passage of the Public Broadcasting Act of 1967 indicated even more dramatic growth and contributions of educational television to the public interest for the future. The emergence of the term "public broadcasting" suggests that the definition of ETV may be made clearer by referring to "public television" as a cultural-public affairs service and to "instructional television" as an academic-informational area.

Inasmuch as the Federal Communications Commission does not license or regulate wired closed-circuit instructional systems, this bulletin will be devoted to educational broadcast stations, translators, microwave systems, and the Instructional Television Fixed Service.

(over)

HISTORY

Educational broadcasting has played an important role in Federal Communications Commission actions since the beginning of public broadcasting. Educational institutions were among the pioneers in experimental aural broadcast which led to the establishment of regular AM broadcasting following World War I. In 1941 the Commission allocated five channels for noncommercial FM broadcasting, increasing the number to twenty in 1945. In April, 1968, more than 345 educational FM stations, and 20 educational AM radio stations were on the air.

In 1949 the FCC invited comments on the advisability of providing channels for noncommercial educational television operation, and on March 22, 1951, as part of a general review of television, the Commission proposed such a course. On April 14, 1952, after extensive proceedings, the Commission opened UHF channels for the expanding TV needs and concomitantly reserved 242 channel assignments (80 UHF and 162 VHF) for noncommercial educational use. These reservations constituted about 12% of the total allocations at that time. The Commission stated:

> "We conclude that the record shows the desire and ability of education to make a substantial contribution to the use of television. There is much evidence in the record concerning the activities of educational organizations in AM and FM broadcasting. It is true and was to be expected that education has not utilized these media to the full extent that commercial broadcasters have, in terms of number of stations and number of hours of operation. However, it has also been shown that many of the educational institutions which are engaged in aural broadcasting are doing an outstanding job in the presentation of high quality programming, and have been getting excellent public response.
>
> "And most important in this connection, it is agreed that the potential of television for education is much greater and more readily apparent than that of aural broadcasting, and that the interest of the educational community in the field is much greater than it was in aural broadcasting . . . The public interest will clearly be served if these stations are used to contribute significantly to the educational process of the nation. The type of programs which have been broadcast by educational organizations, and those which the record indicates can and would be televised by educators, will provide a valuable complement to commercial programming."

The first ETV station to go on the air was KUHT, University of Houston, Texas, on May 23, 1953.

The table of channel allocations, including noncommercial educational reservations, has been revised several times since it was first issued in 1952. The most recent revision, issued in June, 1965 and corrected in March, 1966, provided for 116 VHF and 516 UHF ETV reservations, an increase of more than two-thirds over the previous total of reservations. This table was derived from a computer program, which selected the reservations on an efficiency basis. Deliberately a non-saturated table, this allocations plan was designed for educational organizations to develop a greater number of stations by permitting future computer selection and assignment of unallocated channels to places where at this time ETV may be completely unanticipated.

The steady growth of ETV is illustrated in the following table of stations on the air at the end of each calendar year:

Year	Number	Year	Number
1953	1	1961	62
1954	10	1962	75
1955	17	1963	83
1956	21	1964	99
1957	27	1965	113
1958	35	1966	125
1959	44	1967	151
1960	51	March, 1968	160

A recent fast-growing supplemental service is the Instructional Television Fixed Stations (ITFS), frequently referred to as the 2500 megahertz service. On July 25, 1963 the Commission established the ITFS for the transmission of instructional and cultural materials to schools and other selected receiving locations, following an experiment in the 2000 megacycle (1990-2110) band in the Plainedge, Long Island school district. The Plainview-Old Bethpage Schools, Long Island, was the first to go on the air, on March 2, 1964. In April, 1968, about 50 systems with almost 100 channels were on the air, and more than 55 construction permits for over 200 channels were outstanding.

The Commission also licenses translators and boosters for the relaying of ETV broadcasting, and has jurisdiction over microwaving of ETV signals.

In early 1967, after almost two years of study of the technical, organizational, financial and programming considerations of ETV, the Carnegie Commission on Educational Television published its report, Public Television: A Program for Action. Its recommendations for ETV's future support and development were the bases for the initiation of the Public Broadcasting Act of 1967. This Act provides the means for the necessary increased growth of noncommercial television and radio in the public interest. Title I of the Act extends the matching grant concept of the ETV Facilities Act of 1962; it provides for the inclusion of educational radio for the first time, for the Federal share of costs to be as high as 75%, and for liberalized use of funds for interconnection. Title II of the Act established a Corporation for Public Broadcasting; the CPB is authorized to support the production of program materials for noncommercial television and radio stations, station operation, interconnection of stations, research and training in educational broadcasting, and to serve film and tape library and clearing house functions. Title III of the Act provides for a study of instructional media use and a subsequent report and recommendation to Congress.

ETV BROADCAST STATIONS

About one-third of the ETV broadcast stations are licensed to state or local education systems, about one-third to colleges or universities, and about one-third to community organizations. At first virtually all of the ETV stations were VHF; since 1960 some two-thirds of the CP grants and applications have been in the UHF spectrum, and in late 1967 the number of UHF stations on the air exceeded the number of VHF for the first time. All-channel receiver legislation passed by Congress authorized the FCC to require that all TV sets sold after April 30, 1964 be capable of receiving UHF as well as VHF signals. With the number of VHF unused reservations continually diminishing, the continued growth of UHF ETV stations seems likely. Technological advances, particularly in the use of solid-state devices, have resulted in markedly improved UHF television receivers, thus diminishing the disparity between VHF and UHF coverage.

ETV station programming varies considerably, from in-school instructional materials to performing arts programs for the home viewing audience. Materials are obtained from many sources, including individual stations, private producing organizations, National Educational Television, the National Association of Educational Broadcasters, and Instructional Television Libraries located in Bloomington, Indiana, Boston, Massachusetts, and Lincoln, Nebraska. Local in-school programs, ideally, are locally produced and may be entire series, individual lessons, or part of a lesson such as a demonstration. Reinforcement materials, such as civic tours, visits to cultural sites, and interviews with prominent persons are frequently included. Cultural programming is broad in scope, and includes public affairs programs, many of a probing and controversial nature, interviews with persons in all areas of life, analysis as well as presentations of the performing and plastic arts, and programs for special groups such as children, or on special subjects. Educational television does not usually compete with commercial television insofar as it does not attempt to reach a mass audience with materials representing a common denominator, but tries to reach a large spectrum of minority viewing groups with special interest programs, and a large general audience with common interest programs not available on commercial television. In the spring of 1968 many educational television stations were producing and planning special series and programs to meet the needs of the inner-cities.

In 1967, when National Educational Television began to provide color programming, a number of ETV stations had color transmission capability. By early 1968 most of the remaining stations not already in color had plans for such capability.

The Federal Communications Commission Rules and Regulations has a special section devoted to noncommercial educational stations. Part 73, paragraph 621, reads:

> "In addition to the other provisions of this subpart, the following shall be applicable to noncommercial educational television broadcast stations:
>
> "(a) Except as provided in paragraph (b) of this section, noncommercial educational broadcast stations will be licensed only to nonprofit educational organizations upon a showing that the proposed stations will be used primarily to serve the educational needs of the community; for the advancement of educational programs; and to furnish a nonprofit and noncommercial television broadcast service.
>
> "(1) In determining the eligibility of publicly supported educational organizations, the accreditation of their respective state departments of education shall be taken into consideration.
>
> "(2) In determining the eligibility of privately controlled educational organizations, the accreditation of state departments of education or recognized regional and national educational accrediting organizations shall be taken into consideration.
>
> "(b) Where a municipality or other political subdivision has no independently constituted educational organization such as, for example, a board of education having autonomy with respect to carrying out the municipality's educational program, such municipality shall be eligible for a noncommercial educational television broadcast station. In such circumstances, a full and detailed showing must be made that a grant of the application will be consistent with the intent and purpose of the Commission's Rules relating to such stations.
>
> "(c) Noncommercial educational television broadcast stations may transmit educational, cultural and entertainment programs, and programs designed for use by schools and school systems in connection with regular school courses, as well as routine and administrative material pertaining thereto.

"(d) An educational station may not broadcast programs for which a consideration is received, except programs produced by or at the expense of or furnished by others than the licensee for which no other consideration than the furnishing of the program is received by the licensee. The payment of line charges by another station or network shall not be considered as being prohibited by this paragraph.

"(e) To the extent applicable to programs broadcast by a noncommercial educational station produced by or at the expense of or furnished by others than the licensee of said station, the provisions of §73.654 relating to announcements regarding sponsored programs shall be applicable, except that no announcements (visual or aural) promoting the sale of a product or service shall be transmitted in connection with any program: Provided, however, That where a sponsor's name or product appears on the visual image during the course of a simultaneous or rebroadcast program either on the backdrop or in similar form, the portions of the program showing such information need not be deleted."

INSTRUCTIONAL TELEVISION FIXED SERVICE

The Instructional Television Fixed Service (ITFS) provides 31 channels in the 2500-2690 megahertz (MHz) band. It is designed primarily for classroom instruction (and may additionally be used for the transmission of other special materials to groups or individuals) to selected receiving sites. ITFS relieves the pressure for broadcast ETV allocations and instructional broadcast time on stations when the sole need is for the transmitting of instructional materials over a limited area. Up to four channels may be used by a single licensee so that four different programs may be transmitted and four different classes instructed simultaneously, thus tending to alleviate the scheduling program in the use of TV at many institutions.

ITFS channels are 6 mc/s band width and are organized in seven groups of four and an eighth group of three. ITFS transmitting equipment operates with very low power, with a useful service range of about 20 miles, and is relatively lower in cost than television broadcast equipment. However, while the 2500 MHz signal is transmitted openly, the cost of a special receiving antenna and converter remove the system, for practical purposes, from home use. Special receiving devices convert the signals to regular TV channels so that programs may be seen on conventional TV receivers.

Because technical considerations and operations differ from that of standard VHF and UHF broadcasting, detailed rules and regulations governing ITFS operations have been established. Among the most pertinent considerations are the following: requirements for eligibility to be a licensee of an ITFS station are the same as those for a noncommercial educational television station; transmitter engineers must be technically qualified, but routine operations may be performed by third-class radiotelephone permit holders; remote control and unattended operation of some equipment are provided for; permission to utilize the signal must be obtained by the potential user from the transmitting licensee.

On February 8, 1965, the Commission held a national meeting of those persons in education and industry interested in the development of ITFS, principally to determine ways to meet increasing demands for channels in metropolitan areas. Subsequently, the Commission established, on October 6, 1965, a national Committee for the Full Development of the Instructional Television Fixed Service to operate on national, regional, state and local levels. By early 1968 some 1000 educators on all learning levels, representing varied institutional controls, and from all geographical areas of the country, were participating in ITFS Committees, principally working with local subcommittees to pre-plan maximum efficient use of channels for all potential users in any given area. ITFS applications received by the FCC are sent to appropriate subcommittees for their recommendations.

A booklet, "ITFS: What It Is . . . How To Plan" was developed by the FCC's Committee for the Full Development of the ITFS, and was published for the Committee in 1967 by the National Education Association. It can be ordered from the N.E.A., 1201 Sixteenth Street, N.W., Washington, D.C. 20036.

MICROWAVE, TRANSLATORS, CATV

Microwave relay systems utilize narrow, concentrated beams for efficient short range transmission. Educational TV stations may use microwave equipment to provide program circuits between the studio and transmitter (TV-STL), to relay programs between TV broadcast stations (TV Intercity Relay), and to pick up programs that occur outside regular studios (TV Pickup). The rules governing such TV auxiliaries are contained in Part 74, Subpart F of the FCC Rules, "Television Auxiliary Broadcast Stations." TV program relay facilities for use by closed-circuit TV systems may be authorized on certain microwave channels in the Business Radio Service under Part 91, Section 91.554 of the Rules. Such stations may also be used in connection with ITFS systems. ITFS stations may be used, as well as Studio-Transmitter program circuits, for relaying programs between ITFS systems in adjacent areas, for delivering ITFS programs to TV broadcast stations, and for relaying TV broadcast programs to ITFS systems.

TV translators are devices which change the frequency of an incoming TV broadcast signal and retransmit it on a different TV broadcast channel. They may be used to serve areas not served by the primary broadcast ETV station or ITFS system. No significant changes are made in the technical characteristics of the signal other than frequency and amplitude. Many school districts construct and operate translators, and many stations operate their own translators in order to boost their signals into outlying areas for both school and community programming. TV translators may not operate as independent broadcast stations.

CATV (Community Antenna Television) systems pick up TV signals and place them on cables to homes or public buildings in a given community which, for reasons of terrain or otherwise, would not be able to pick up that particular signal with as much clarity, if at all. A number of ETV stations are carried by CATV, and many educational institutions utilize this service. Under current rules (Part 74, Subpart K, "Community Antenna TV Systems"), CATV systems are obliged upon request to carry the signal of an ETV station within whose Grade B or higher priority contour the system operates and, with certain exceptions, to afford same day program exclusivity to such stations as against the programs of lower priority stations.

FINANCING

Different types of ownership mean different types of budgets and sources of funds. On the average, stations operated by colleges and universities and by school systems obtain about 75% of their income from direct budgeted support. Stations operated by state agencies receive about 95% of their funds from state appropriations. Community stations, on the other hand, receive about 75% of their support from gifts, grants, and services, the latter primarily for the production of in-school programs. ITFS systems are supported by the local instutitional licensee, in some instances with the aid of Federal grants.

As early as 1952, the FCC recognized the incipient financial difficulties confronting ETV when it stated:

> "It will admittedly be a difficult and time consuming process in most instances, but the likelihood of ultimate success, and the importance to the public of the objective sought, warrants the action taken . . . Television is clearly a fertile field for endowment, and it seems probable that sufficient funds can be raised both through this method and through the usual sources of funds for public and private education to enable the construction and operation of many noncommercial educational stations. As concerns the costs of operation, there is the possibility of cooperative programming and financing among several educational organizations in large communities."

Public and Private financing have greatly assisted ETV. The Ford Foundation's Fund for the Advancement of Education has been one of ETV's principal supporters. Currently the Ford Foundation is providing funds for National Educational Television and for educational television and radio stations, and the Carnegie Corporation, among others, is assisting public television study and development.

The Carnegie Commission report of January, 1967, Public Television, showed that of the total source of funds for all ETV stations, 27.1% came from state government, 18.9% from local government, 14.4% from foundations, 11.8 percent from the federal government, 11.2% from state universities, 5.5% from subscribers, 3.5% from business and industry, 1.9% from underwriting, and 5.7% from other sources. Of total operating costs of all stations, 37.9% went for program expenses, 31.2% for general and administrative, and 30.9% for technical. The median station operating expense was $258,510. Selected items showed 52.9% of total station expenses went for wages and salaries, 6.1% for fund raising and promotion, and 2.7% for outside programs.

The Public Broadcasting Act of 1967, Title I, is an extension and enlargement of the Educational Television Facilities Act of 1962, which provided matching Federal grants of up to one million dollars per state for the construction and expansion of ETV facilities, to a total of $32 million until its expiration in 1967. The 1967 Act has an authorization of $38 million for three years beginning fiscal year 1967 (subject to appropriation). The federal share is increased to a maximum of 75% with no limit on interconnection. An individual state is limited to 8½% of each annual appropriation. Title I of this Act--Public Law 90-129--is administered through the Department of Health, Education, and Welfare.

The Corporation for Public Broadcasting, Title II of the 1967 Act, is not an agency or establishment of the United States government. Its function is to provide funds for various purposes, including programming, interconnection, operational costs, research, demonstration, training and public information.

Other government legislation helpful to both broadcast ETV and ITFS includes the Elementary and Secondary Education Act of 1965, especially Title I, assistance for educationally deprived children, Title II, providing printed and audio-visual materials, and Title III, supplementary educational centers and services; the Higher Education Act of 1965, especially Title VI, the acquisition of closed-circuit instructional television equipment, materials and minor remodelling of TV facilities; the National Defense Education Act of 1958, especially Title III, strenghtening instruction in science, mathematics, modern foreign languages and other critical subjects, and Title VII, research and experimentation in television, radio, motion pictures and related media. Other significant support may come from the Vocational Education Act of 1963; the Appalachian Regional Development Act of 1965, especially Title I, Special Appalachian Programs; the Economic Opportunity Act of 1964,

(over)

particularly Title I, Youth Programs, and Title II, urban and rural community action programs; the State Technical Service Act of 1965; and from the Public Health Service for research, demonstration and programming, particularly from the National Institutes of Health, the National Institute of Mental Health, and the Division of Nursing of the Bureau of Health Manpower.

APPLICATION PROCEDURES

The Commission's Table of Assignments, Section 73.606 of the Rules and Regulations, contains the educational reservation status and frequencies of TV broadcast channels allocated to a given city. An educational organization or institution may apply for a reserved or nonreserved channel. Funds available through Title I of the Public Broadcasting Act of 1967, however, are allocated to permittees or licensees on reserved channels only, unless the Construction Permit had been obtained prior to May 1, 1962.

If there is no reserved channel in a given community, a qualified group may petition for reservation of an unused assigned channel, for the "drop-in" assignment of a channel, or for the reallocation of a channel from another city. The petition must clearly delineate the purpose of the proposal and show why it would be in the public interest. If the Commission determines the proposal warrants consideration, it will institute rule-making proceedings, and if the assignment is subsequently made, an application may then be made to activate the channel.

Virtually all prospective applicants obtain legal and engineering counsel to assist in supplying required and accurate information to the Commission. Expeditious processing frequently is dependent upon the good order of the application and the completeness, specificity and preciseness of the information.

Applicants for new broadcast stations, license renewals, or major changes in existing facilities, must give local public notice of intent, through a local station (if any) and/or in a local newspaper, as specified in Section 71.580 of the Rules and Regulations.

All broadcast applications must be submitted in triplicate to the Secretary, Federal Communications Commission, Washington, D. C. 20554. After they are tendered, if complete and in conformity with the rules, they are formally accepted for filing and assigned a file number. An application is not acted upon until at least 30 days following acceptance, during which period it is subject to objecting petitions. Processing of applications involve three major areas of examination and review: Engineering, Financial and Legal. The engineering examination verifies calculations to determine if they conform to the technical requirements of the Commission's rules. The Antenna Survey Branch determines whether the proposed antenna structure meets Federal Aviation Agency regulations. An accountant checks the financial qualifications, including adequacy of resources and matters such as discrepencies between estimated and potential actual operating costs, and total costs balanced against particular costs. The financial examination is particularly concerned with verification of the source of funds: whether the applicant has the necessary funds, available or committed, to construct and operate the station for one year, including Educational Television Facilities Act grants if applied for, or has been given the authority to use the money, bonds, securities or other finances described in the application. Attorneys determine whether the applicant is qualified under the Communications Act to become a licensee. They review technical and economic findings, check the corporate structure, determine if there are any matters before the Commission which might affect the applicant, and analyze the Statement of Program Service.

When an application for a new station or for changes in an existing facility is approved, a Construction Permit (CP) is issued. The permittee has 60 days in which to begin construction, and a period of six months thereafter for completion of the project. If the station cannot be constructed in the specified time an extension may be applied for. Following issuance of the CP the permittee may request call letters, with the first available preference assigned. Within 30 days from the time the CP is issued the permittee must submit an Ownership Report. This report also must be filed with each application for a license renewal, and within 30 days of a change of officer or ownership of the station.

When construction of the facility is complete in accordance with the CP, the permittee may conduct equipment tests, following notification to the Commission. Application for the license may be submitted, accompanied by measurements of equipment performance. At the same time--but at least ten days *before regular programming* is scheduled to begin--Program Test Authority (PTA) may be requested. PTA is contingent upon approval by the FCC of performance data as detailed in the license application. In effect, PTA entitles the permittee to begin regular station operation and programming, although the license itself is not granted until the license application receives final approval. Renewal dates vary by geographical region; a new licensee must file his first renewal at the first date specified for his state; thereafter licenses are normally issued for three year periods.

Channels for ITFS stations are selected on a case-by-case basis. There is no pre-planned assignment table in the rules, although community pre-planning is desirable. The booklet mentioned on page 7 of this bulletin offers valuable suggestions in applying for ITFS systems.

Education television applications, requests and reports are submitted on the following forms:

FCC Form 340: Application for Authority to Construct or Make Changes in a Non-commercial Educational TV, FM, or Standard Broadcast Station.

FCC Form 341: Application for Noncommercial Educational TV, FM, or Standard Broadcast Station License.

FCC Form 342: Application for Renewal of Noncommercial Educational TV, FM, or Standard Broadcast Station License.

FCC Form 330P: Application for Authority to Construct or Make Changes in an Instructional Television Fixed Station.

FCC Form 330L: Application for Instructional Television Fixed Station License.

FCC Form 343: Application for Authority to Construct or Make Changes in a Television Broadcast Booster Station.

FCC Form 344: Application for Television Broadcast Booster Station License.

FCC Form 345: Application for Renewal of Television Broadcast Booster Station License.

FCC Form 346: Application for Authority to Construct or Make Changes in a Television Broadcast Translator Station.

FCC Form 347: Application for Television Broadcast Translator Station License.

FCC Form 348: Application for Renewal of Television Broadcast Translator Station License.

FCC Form 313: Application for Authorization in the Auxiliary Broadcast Services.

FCC Form 318: Request for Subsidiary Communications Authorizations.

FCC Form 701: Application for Additional Time to Construct Radio Station.

FCC Form 321: Application for Construction Permit to Replace Expired Permit.

FCC Form 323E: Ownership Report for Noncommercial Educational TV, FM, or Standard Broadcast Station.

NETWORKS AND PROGRAMS

At the beginning of 1968, no full-time live nationwide ETV network existed, although National Educational Television (NET) had on numerous occasions interconnected ETV stations nationally for special programs. The Public Broadcasting Laboratory of NET, funded by the Ford Foundation for a two year period, began broadcasting on a national ETV hookup on November 5, 1967 a Sunday evening experimental series of cultural, informational and public affairs programs. In early 1968 NET had well-advanced plans for full-time interconnection.

NET has become known as the "fourth network," supplementing and offering an alternative service to the three commercial networks. NET provides taped programs to more than 133 affiliated ETV stations. Funded primarily by the Ford Foundation, NET offers its affiliates five hours per week of original programs, one and one-quarter hour per week of new children's programs, and access to a large library of programs for re-run. The bulk of the programs are produced by the NET staff; in addition, with NET supervision, programs are produced by affiliated stations and by independent producers.

The National Association of Educational Broadcasters (NAEB) established in late 1965 a program service to its members under its Educational Television Stations Division. Several hours a week of programs are made available from ETV stations and other sources. These are distributed through a tape network arrangement from the ETS Program Service, 317 East Second Street, Bloomington, Indiana 47401.

Instructional materials are distributed on a national basis by the Great Plains National Instructional Television Library, Lincoln, Nebraska, by the National Center for School and College Television, Bloomington, Indiana and by the Midwest Program for Airborne Televised Instruction, Lafayette, Indiana (see pages 15-16).

At the beginning of 1968 the Eastern Educational Network (EEN) was the only physically interconnected ETV regional network. The EEN provides in-school and evening taped programs to 23 stations and simultaneous evening interconnection for

17 stations in Maine, Vermont, New Hampshire, Massachusetts, Connecticut, New York, Pennsylvania, Delaware and Washington, D.C. EEN supplies about one-third of the programming used by its affiliates.

In early 1968, in addition to the Eastern Educational Network, there were five other regional ETV networks in various stages of operation: Central Educational Network, Inc., Chicago and the surrounding area; Midwest Educational Television, Inc., in Minnesota and neighboring states; Rocky Mountain Network; Southern Educational Communications Association; and Western Educational Network. Although some of the stations have microwave or off-the-air interconnection, most stations are serviced by taped program distribution.

Almost every individual State is in the planning or active stage of an interconnected network, and some 25 States have already linked stations toward eventuation of total intrastate coverage. Complete networks are in operation in such states as Alabama, Connecticut, Georgia, Maine, Nebraska, South Carolina and Vermont.

Although The Ford Foundation has made detailed proposals for a non-profit educational satellite corporation, and COSMAT has indicated its willingness to accomodate educational signals on a domestic communications satellite, no immediate plans existed in 1968 for activation of a domestic satellite for educational purposes. Global satellites have been used for some educational programs; National Educational Television initiated U. S. participation in worldwide simultaneous interchange with a program in mid-1967.

ORGANIZATIONS

The National Association of Educational Broadcasters, 1346 Connecticut Avenue, N.W., Washington, D.C. 20036, represents radio and television stations, educational institutions and organizations, state agencies, industrial firms, state educational broadcasting associations, and individuals participating in or interested in educational broadcasting. The NAEB provides consultation, conducts research, distributes information, represents educational broadcasters to government, and publishes materials which aid in the development of educational television and radio. Its operations include: Educational Television Stations Division, National Educational Radio Division, Instructional and Professional Services Division, and an Office of Research and Development. Also associated with the NAEB is the State Educational Television Association (Council of Educational Telecommunications Authorities), made up of the chief planning officers of state educational telecommunications systems. The NAEB publishes a comprehensive "Directory and Yearbook of Educational Broadcasting."

National Educational Television, 10 Columbus Circle, New York, N.Y. 10023, as described earlier, serves virtually all the country's educational television stations with programming. NET maintains a Washington, D.C. office at 1619 Massachusetts Avenue, N.W., 20036.

The National Citizens Committee for Public Television, 609 Fifth Avenue, New York, N.Y. 10017, seeks widespread support of PTV through public information programs, institutional advertising, and participation of national organizations in all fields. It advises state and local citizen committees, aids in the development of TV art forms, and conducts studies for permanent financing of the corporation for Public Broadcasting.

The Joint Council on Educational Telecommunications, 1126-16th Street, N.W., Washington, D.C. 20036 (formerly the Joint Council on Educational Broadcasting), is comprised of leading educational organizations. JCET acts as a channel of communication between educational interests, broadcasting, and Federal offices and Congress on national issues affecting educational telecommunications, and is concerned with cooperative inter-institutional efforts that can be facilitated by any form of electronic interconnection.

The Department of Audio-Visual Instruction (DAVI) of the National Education Association, 1201-16th Street, N.W., Washington, D.C. 20036, holds conferences, conducts research projects, publishes reports and provides consultation on educational media, including television, for its member schools and teachers on national, regional and local levels. NEA also has a Television Consultant office.

The Educational Media Council, 1346 Connecticut Avenue, N.W., Washington, D.C. 20036, is composed of representatives of education and industry. It provides a forum on instructional problems, stimulates communications research and development, disseminates information, and conducts educational communications projects.

The Association for Professional Broadcasting Education, 1812 K Street, N.W., Washington, D.C. 20036, provides materials and guidance in educating people for careers in broadcasting.

The Southern Educational Communications Association (SECA), 928 Woodrow Street, Columbia, South Carolina 29205, provides programming and production assistance to TV and radio stations, educational institutions and industry; grant application, copyright clearance and utilization assistance; engineering consultation; and a library of aural and visual materials for its members in the southeastern states.

The Western Radio and Television Association, 1313 North Vine Street, Hollywood, California 90028, coordinates conferences, assists in utilization and distributes information concerning ETV and ITV use on the west coast.

The National Center for School and College Television, Indiana University, Bloomington, Indiana 47405, serves as a distribution and information center. Its purposes are to provide wide circulation of instructional programs, encourage quality production of telecourses, establish a research and dissemination service, and initiate a grant service for the production of programs.

The National Great Plains Instructional Television Library, University of Nebraska, Lincoln, Nebraska 68508, serves as a distribution center of instructional courses for all academic levels and content areas, and provides information services on utilization.

The Midwest Program for Airborne Instruction, Inc. (MPATI), Purdue University, Lafayette, Indiana 47902, in the spring of 1968 ended its seven year program of transmitting instructional programs from aircraft to schools and colleges in six midwestern states. MPATI is now serving as a source for taped instructional programs on all grade levels.

The national Committee for the Full Development of the Instructional Television Fixed Service, Federal Communications Commission, Washington, D.C. 20554, was established in late 1965 to serve as a liaison, informational and advisory group on 2500 MHz on national, regional, state and local levels. Its members represent, principally, non-profit educational institutions and organizations.

Other groups on the national level, such as the College Conference Division of the International Radio and Television Society, are involved in educational television activities. Many regional, state and local groups, such as the Southern Regional Education Board, are active in educational broadcasting matters.

GOVERNMENT AGENCIES

Special offices relating to educational broadcasting have been established on State and Federal levels.

The Educational Broadcasting Branch, Federal Communications Commission, Washington, D.C. 20554, has as its purpose the facilitation of the development of educational broadcasting, including all forms of radio and television for which the FCC is responsible. The Branch is involved in the development of rules and regulations governing educational broadcasting, is concerned with interagency educational broadcasting affairs, and provides informational, liaison and guidance services.

The Department of Health, Education, and Welfare has two offices responsible for Title I of the Public Broadcasting Act of 1967, which provides matching grants for the construction or expansion of ETV and radio broadcasting facilities. The office of the Assistant, for Educational Television, to the Assistant Secretary (Education), Department of Health, Education, and Welfare, 330 Independence Avenue, S.W., Washington, D.C. 20201, administers the program; the ETV Facilities Branch, Office of Education, 7th and D Streets, S.W., Washington, D.C. 20201, processes applications.

The Office of Education, Department of Health, Education, and Welfare, 400 Maryland Avenue, S.W., Washington, D.C. 20201, administers most of the other grants available for educational television, through several of its bureaus, including the Bureau of Research, the Bureau of Elementary and Secondary Education and the Bureau of Higher Education. See page 9 for further information on HEW grant services.

The General Services Administration, 18th and F Streets, N.W., Washington, D.C. 20405, administers the Federal Property Act, which authorizes donations of surplus property, equipment and land, which may be applied for by tax exempt radio and television stations.

Many other Federal agencies offer grants, program materials, or production contracts to educational television stations. Among the most active are the Radio and Television Office of the National Aeronautics and Space Administration; Special Projects Program, National Science Foundation; and the Radio-TV Section, Department of Agriculture. The Federal Interagency Broadcast Committee, consisting in early 1968 of 31 departments/agencies with radio-television responsibilities, does not provide grants, but is a planning and recommendation group which includes ETV as one of its concerns.

Most States have established educational broadcasting or educational television offices or commissions, principally to coordinate activities for the development of State networks. Instructional television offices are found in many Departments of Education or Departments of Public Instruction. Many county and local school systems and even individual schools have ETV coordinators for the purpose of achieving effective utilization of closed-circuit, instructional fixed and broadcast television. Many colleges and universities, public and private, have persons responsible for ETV development and use. State and local ETV councils and citizens organizations are sometimes quasi-official in that many of their members and directors are public officials.

- FCC -

APPENDIX III

WHERE TO GET HELP

Help is obviously where you find it, and the following is not intended to be definitive. There are competent advisers on the faculties of many universities, and there are valuable lessons to be learned from many fine operating systems.

But while good examples and qualified people come and go, some sources of help, bless them, seem to go on forever. As you develop plans for your own system, you may wish to consult the latest specialized publications or visit people responsible for comparable projects. There's no such thing as an up-to-date list of these "latest and best" publications and projects, because the situation changes day by day. But the professionals who man the following offices can be enormously helpful in steering you to the right consultant or the latest book or the model installation.

National Education Association

1201 Sixteenth Street N.W.
Washington, D.C. 20036

The NEA and its various departments have conducted studies and produced publications on subjects ranging from the rights and responsibilities of teachers to specific publications on cable television systems, the Instructional Television Fixed Service, and the problems and opportunities of planning educational facilities using new media. The Department of Audio-visual Instruction (DAVI) has done much work with ITV and its relationship to other media as well as the total instructional problem. Under the leadership of the indefatigable Harold Wigren, NEA has figured prominently in the long evolution of a new copyright law and in the development of ITFS.

National Association of Educational Broadcasters

1346 Connecticut Avenue N.W.
Washington, D. C. 20036

The NAEB is the professional association of educational broadcasting. Through its Educational Television Stations and National Educational Radio divisions, NAEB represents the great preponderance of educational broadcasting station operators in the country. For our present purposes, however, it is important to emphasize that this organization established and supervised the landmark instructional television project in American Samoa, undertook the Educational Communications System study on telecommunications networks, conducted the important National Project for the Improvement of Televised Instruction and has participated in the design of many ITV systems around the world. Through its Instructional and Professional Services Division, NAEB serves the interests of those who use television and radio for instructional and administrative purposes.

Joint Council on Educational Telecommunications

1126 Sixteenth Street, N.W.
Washington, D. C. 20036

This is a council of associations, formed to assist the educational community with regard to the development of technology for education. Originally formed as the Joint Committee on Educational Television, its mission was to secure reserved channels for ETV in the FCC deliberations of 1950-52. Including such powerful groups as the American Council on Education, the Council of Chief State School Officers, the NEA, NAEB, and half a dozen others, JCET has evolved into a group that essentially establishes an education perspective on developments in the entire field of telecommunications, from telephones to satellites and beyond.

American Association of University Professors

1785 Massachussetts Avenue, N.W.
Washington, D. C. 20036

The AAUP can hardly be said to have a major interest in educational technology per se, but has done some very thoughtful work regarding the relation of professors to television and other new media.

National Society of Professional Engineers

2029 "K" Street, N.W.
Washington, D. C. 20006

As indicated in our text, this Society is much concerned about standards of engineering practice, and it has published standards, operating guidelines, and related helpful information. Many state societies are affiliated with the National Society: some statements of the Florida Engineering Society are quoted at length above. In searching for engineering help, it is also well to bear in mind that many states register qualified professional engineers, and the state registries may help you find your consulting engineer.

EDUCOM, the Interuniversity Communications Council

9650 Rockville Pike
Bethesda, Maryland 20014

EDUCOM is a relative late comer among these groups. It began with a base in the medical sciences, but its interests broadened at once to include the full range of communication problems faced by universities.

Federal Communications Commission

Washington, D. C. 20025

The FCC is a central fact of instructional communications, since it regulates educational television and radio stations, ITFS systems, common carriers such as telephone companies, and, to an increasing extent, cable systems. The FCC has taken a generally sympathetic attitude toward the requirements of education, reserving broadcasting channels and creating the Instructional Television Fixed Service. Through its Educational Broadcasting Branch, the Commission offers valuable information about the many fields within its purview.

FCC Committee for the Full Development of the Instructional Television Fixed Service

% Federal Communications Commission
Washington, D. C. 20025

This committee and its various regional groups act as a valuable coordinating agency as ITFS develops throughout the country. In addition, the Committee has worked to provide much information about this extremely useful television service.

Department of Health, Education, and Welfare

U. S. Office of Education
Washington, D. C. 20202

It should be recalled that USOE is valuable not only as a source of grant funds but as a fountain of information. Through the Educational Research Information Center (ERIC) and through the expertise of the USOE staff, an amazing amount of material is available regarding educational technology.

Educational Media Council

1346 Connecticut Avenue, N.W.
Washington, D. C. 20036

EMC is a meeting ground for education and the industries involved in educational media. Its magnum opus is the Educational Media Index. EMC is a continuing source of information both as an entity and through its varied constituency.

Corporation for Public Broadcasting

(NO ADDRESS AS THIS IS WRITTEN)

The Corporation for Public Broadcasting was created by the Public Broadcasting Act of 1967, as a major force in the support and development of noncommercial broadcasting in the United States. While its mission does not bear directly on instruction, its support of educational broadcasting stations can hardly fail to be of vital importance to all segments of educational telecommunications.

Ford Foundation

320 East 43rd Street
New York, N.Y. 10017

The Ford Foundation has supported an impressive amount of research and thoughtful writing about education and the applications of technology. Lists of Foundation publications are available upon request. Many of them are very much to the point.

Educational Facilities Laboratories, Inc.

477 Madison Avenue
New York, N. Y. 10022

EFL has produced some landmark publications about facilities that make use of television and other new media. Well researched and handsomely presented.

SOFTWARE

The sources above can offer help on a great many subjects. The following agencies are sources of programs. They can tell you what's available, for how much money, and when. National Educational Television is not centrally involved in instruction, but is included because of its importance to educational television nationally and because certain of its products have much importance to education.

National Center for School and College Television

Box A
Bloomington, Indiana 47401

Great Plains National Instructional Television Library

University of Nebraska
Lincoln, Nebraska 68508

Midwest Program on Airborne Television Instruction

Memorial Center
Purdue University
Lafayette, Indiana

National Educational Television

10 Columbus Circle
New York, N. Y. 10019